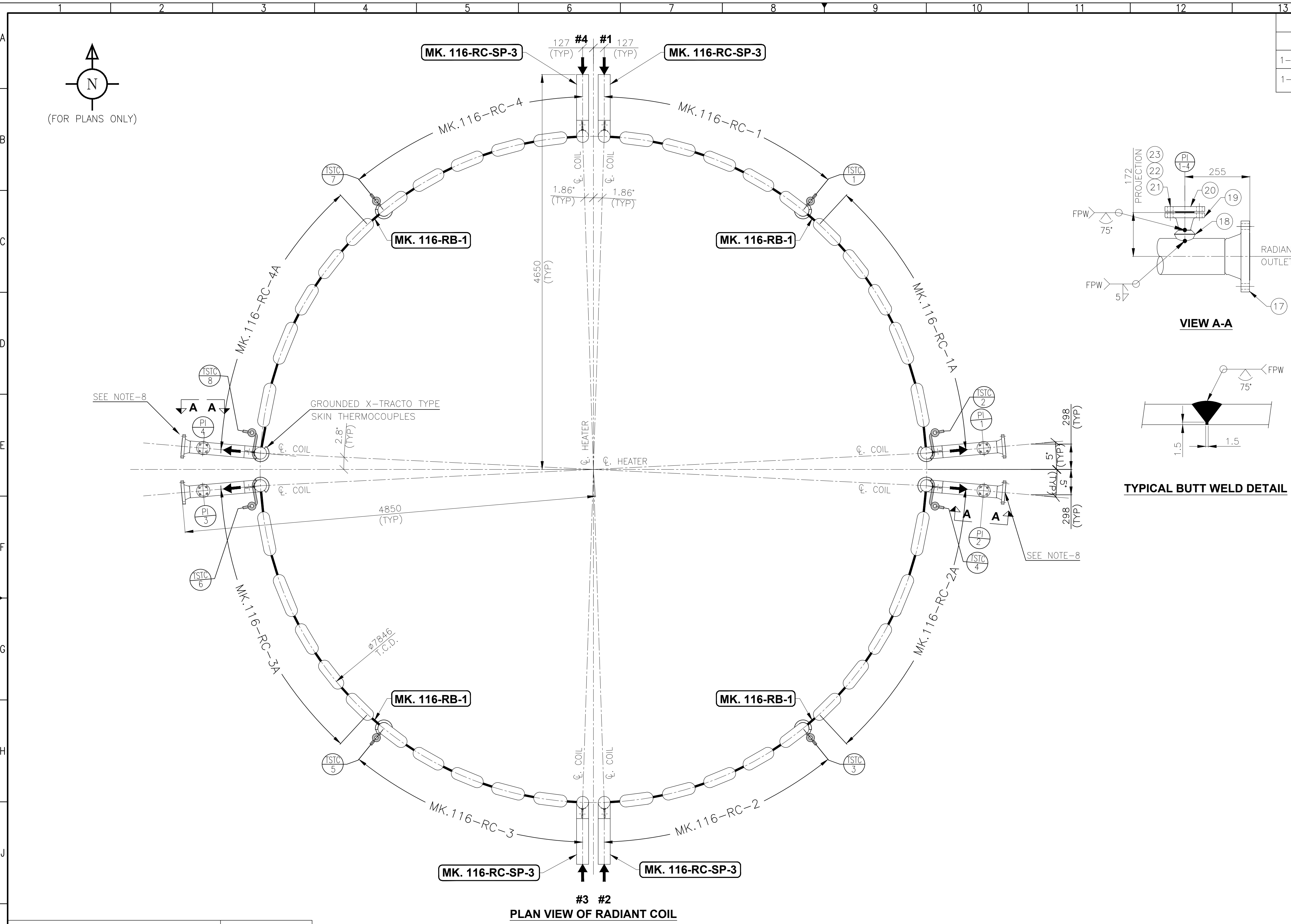
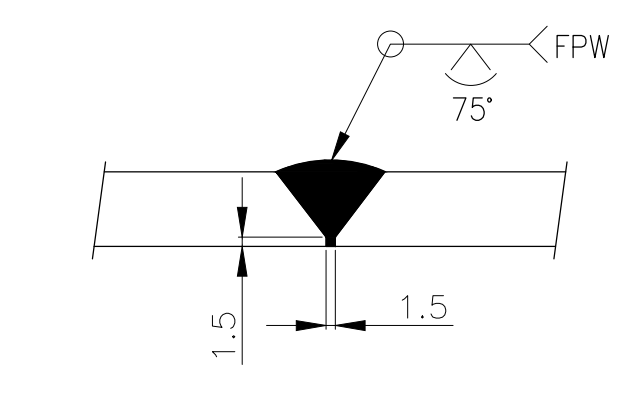
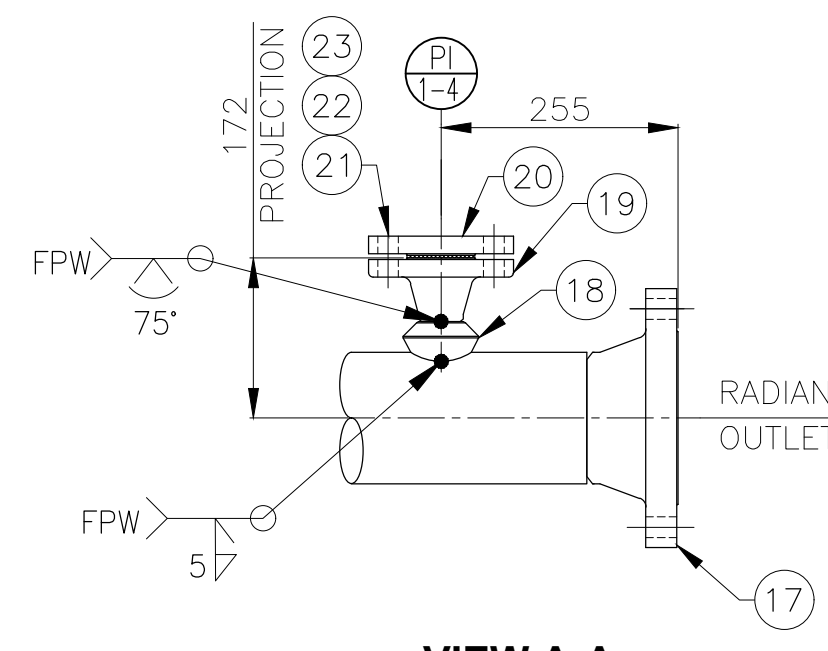




REFERENCE DRAWINGS		
DRAWING NO.	TITLE	PMC/CUST.DRG.NO.
1-48-800-U6018	GA-ELEVATION & PLANS	6745-PRC-412-DZ-0002-001
1-11-002-U8048/49/50	DETAILS OF CONVECTIVE COILS & X-OVER	6745-PRC-412-DZ-0002-004

- NOTES :-**
- ALL DIMENSIONS AND UNITS ARE IN MM.
 - ELEVATIONS GIVEN ARE RELEVANT TO REF. GRADE EL+0000.
 - ALL ITEMS SHALL BE CHECKED BY FULL SCALE LAYOUT BEFORE FABRICATION.
 - NO UNDER CUT OF PIPE WALL IS PERMITTED DUE TO WELDING.
 - COMPLETED ASSEMBLIES TO BE SHOP HYDRO TESTED AFTER COMPLETION OF WELDING AND ALL STATED INSPECTION REQUIREMENTS.
 - COIL SHALL BE DRIED AFTER HYDROTEST.
 - ALL WELD PREPARATION SHALL CONFORM TO ANSI B16.25.
 - ALL FLANGE BOLT HOLES SHALL STRADDLE NATURAL CENTER LINES.
 - ALL COIL WELDS MUST BE FULL PENETRATION TYPE.
 - ALL PIPES AND FITTINGS SHALL BE SEAMLESS TYPE.
 - PWHT SHALL BE CARRIED OUT ON PRESSURE PART WELD AS PER PROJECT SPEC.
 - 100% RT REQUIRED FOR ALL WELDS AFTER PWHT.
 - 100% PMI TESTING REQUIRED ON ALLOY PRESSURE PART WELDS INCLUDING WELD FILLER MATERIALS.
 - GENERAL ENGINEERING SPECIFICATION FOR FIRED HEATER DOC. NO. 6745-PRC-000-EC-003.
 - EIL ENGINEERING DESIGN BASIS (PART-B) DOC. NO. B269-999-02-42-ODB-1001.
 - ENGINEERING DESIGN BASIS FIRED HEATER EQUIPMENT MECHANICAL DOC. NO. B269-999-80-44-EDB-1001.
 - TECHNICAL SPECIFICATION FOR PIPE, FITTING, FLANGES, GASKET & FASTENERS DOC. NO. 6745-PIP-EC-0001.
 - DELETED
 - SPECIFICATION FOR POSITIVE IDENTIFICATION (PMI) AT SUPPLIER'S WORK DOC. NO. 6745-PIP-EC-0006.
 - THERE ARE TOTAL OF 88 TUBES IN 4 PASSES IN RADIANT SECTION. LAST 4 TUBES IN EACH PASS ARE SPACED AT 3D PITCH (381 MM) ON EITHER SIDES. BALANCE TUBES ARE SPACED AT 2D PITCH (254 MM) WITH D BEING NOMINAL DIA. OF TUBE.
- 21. LEGEND:-**
- | | |
|-----|-------------------------|
| BBE | : BEVELED ON BOTH ENDS |
| • | : INDICATES SHOP WELD |
| ✕ | : INDICATES FIELD WELD |
| FPW | : FULL PENETRATION WELD |
| EL. | : ELEVATION |
| C/C | : CENTER TO CENTER |
| ℄ | : CENTER LINE |



DESIGN CONDITIONS	
DESIGN CODE (TUBE)	API 530
DESIGN PRESSURE, ELASTIC/RUPTURE, (KG/CM ²)(G)	29.5/29.5
DESIGN FLUID TEMP. (°C)	390
DESIGN TUBE METAL TEMP. (°C)	510
SHOP HYDROTEST PRESSURE (KG/CM ²)(G)	63
FIELD HYDROTEST PRESSURE (KG/CM ²)(G)	63
CORROSION ALLOWANCE-COIL(MM)	3
RADIOGRAPHY: (ALL PRESSURE PART)	100%
POST WELD HEAT TREATMENT	YES

PROCESS CONNECTION					CONNECTION: MAX. ALLOWABLE FORCE (N), MOMENTS (N.m) (5 x API 560)						MAXIMUM ALLOWABLE MOVEMENTS (mm)			SIGN CONVENTION FOR TERMINAL MOVEMENTS AND LOADS.	
ITEM	QTY.	DESIGNATION	MATERIAL	ELEVATION	Fx	Fy	Fz	Mx	My	Mz	X	Y	Z		
OUTLETS	4	5" NPS x SCH.40 300# RFWN FLANGE	A182-Gr.F9	EL.+20286	5005	10010	10010	4475	3390	3390	0	±25	±25		

Rev.	Date	Name	Date	Name	Date	Name	Description	Acc. Code
03	12.08.2023		12.08.2023		12.08.2023		REVISED AS MKD. 3	
02	20.02.2023		20.02.2023		20.02.2023		REVISED AS MKD. 2	
01	03.01.2023		04.01.2023		04.11.2023		REVISED AS MKD. 1	
00	31.10.2022		07.11.2022		07.11.2022		FIRST ISSUE	
Rev.	Date	Name	Date	Name	Date	Name	Description	Acc. Code
Drawn	31.10.2022	A.G.F.I.S	Prepared	31.10.2022	RAJU	Checked	07.11.2022	S.VIJAY/A.N.V.K.KISHORE
Approved	07.11.2022	S.K.BISWAS						

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☐ 4 For Engineering
☐ 5 For Enquiry
☐ 6 For Order Placement
☐ 7 Final & Approved
☐ 8 Released for Construction

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☐ 2 Approved for Manufacturing/
Fabrication With Comments
as Marked
☐ 3 Not Approved/Resubmit
☐ 4 Retained for Information/Records
☐ 5 Reviewed
☐ 6 Reviewed as Noted/Resubmit

Date : _ / _ / _ Name : _

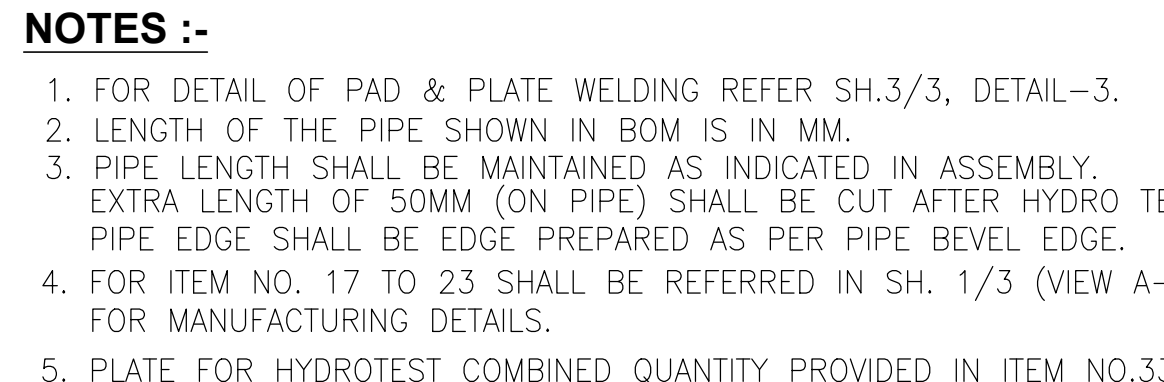
Contract No. **66-6745** Document ID **6745-PRC-412-DZ-0002-003** Part Rev. **FOA/04 03**

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Store Location: Folder
Store Name

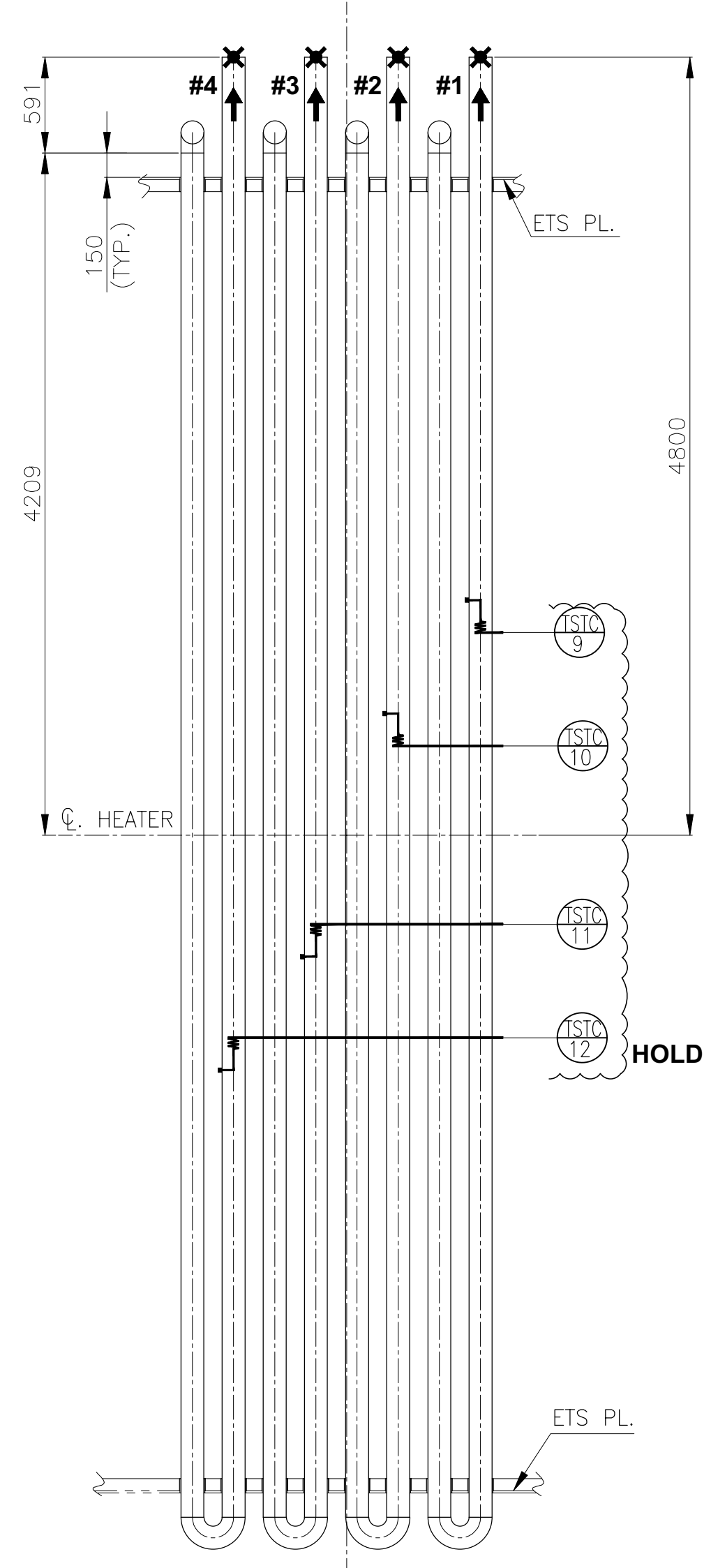
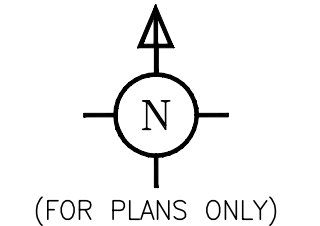
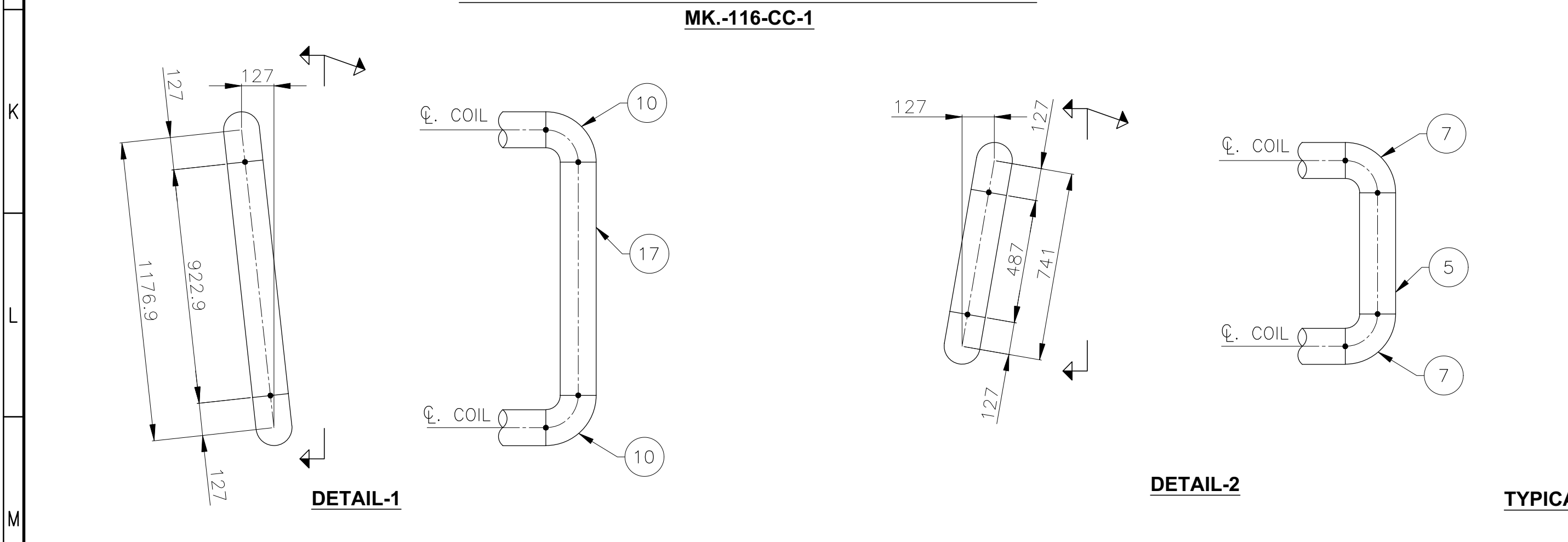
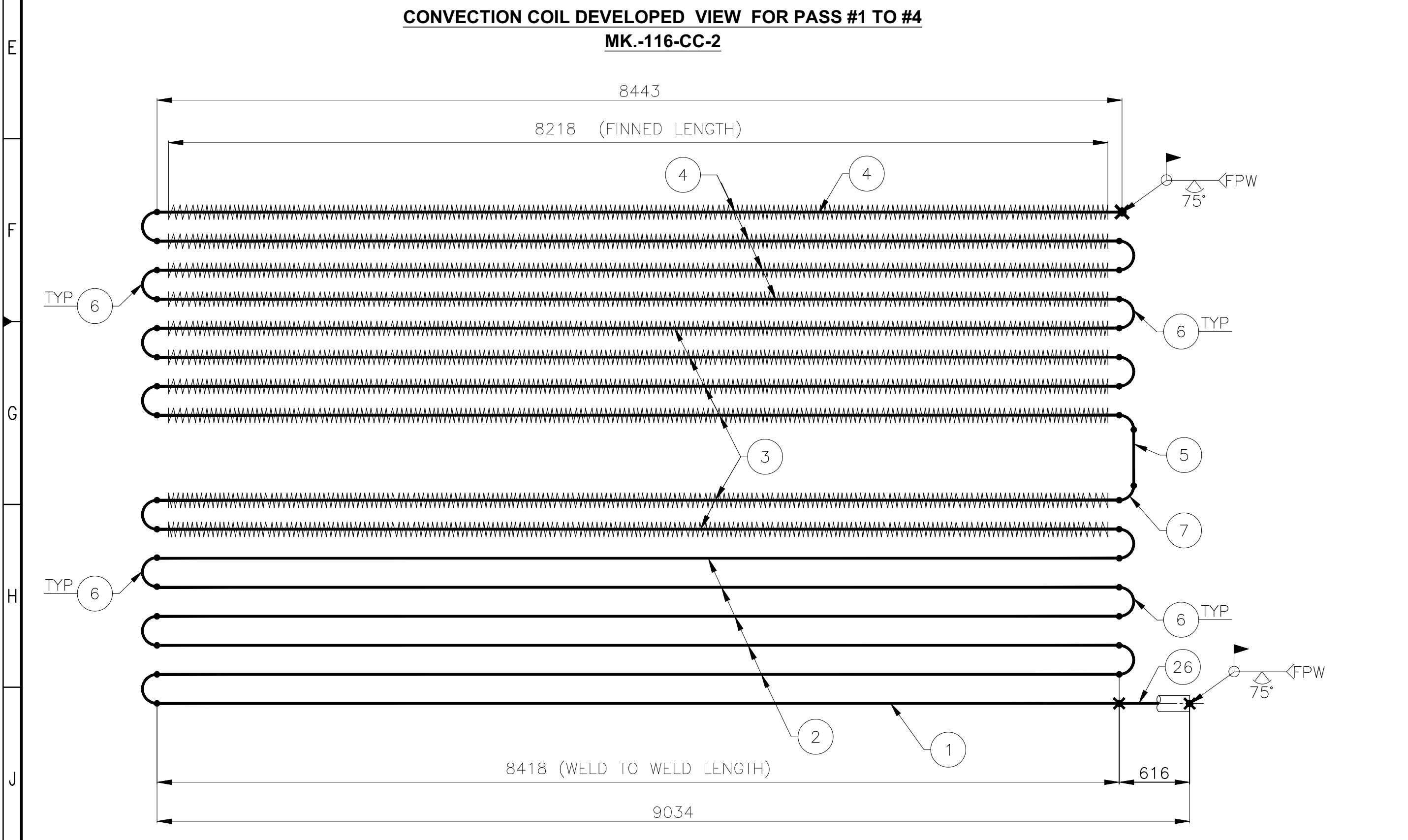
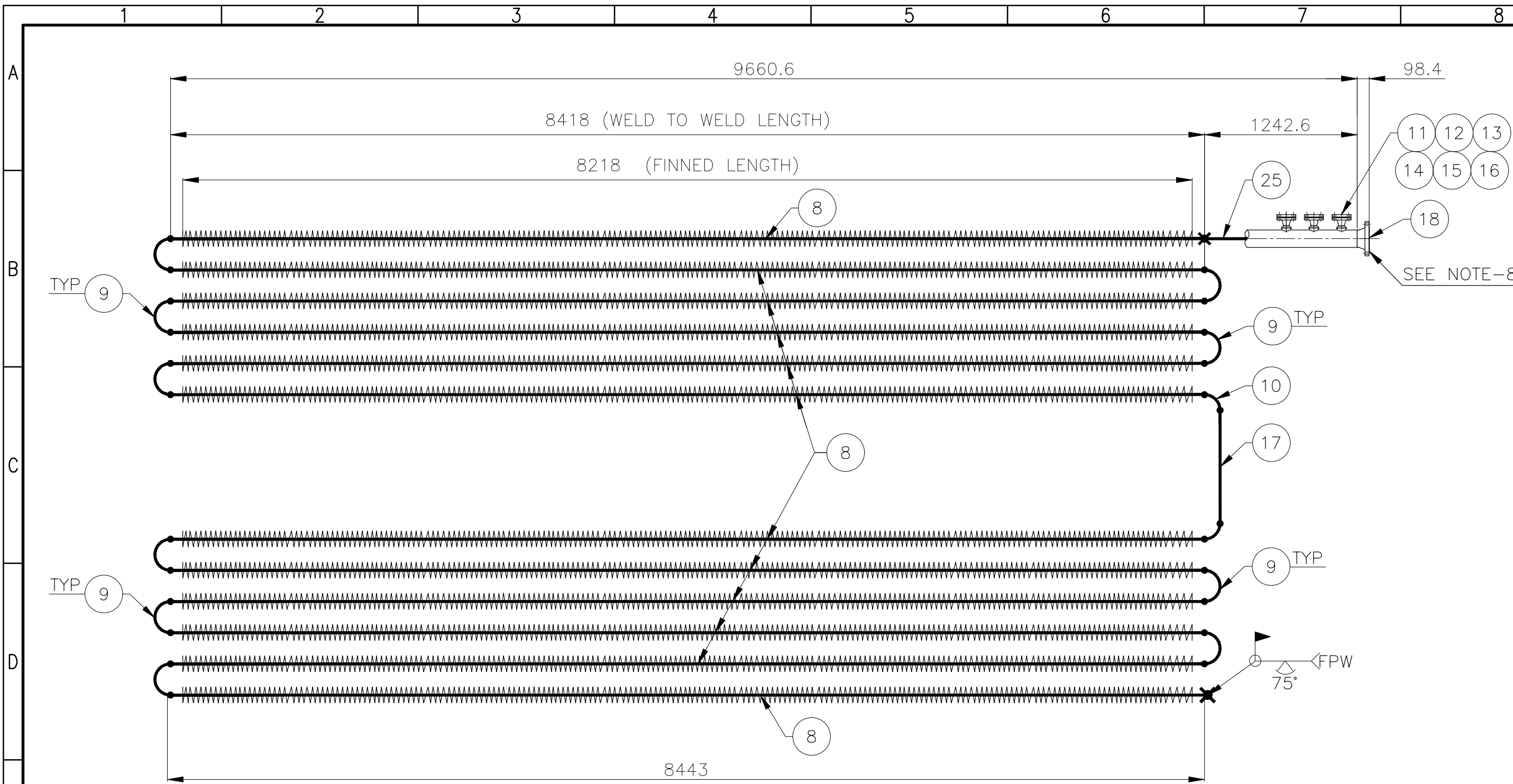
Proc. Unit **412** Con. Unit **412-H-001** Group **412** Order No. **412** Type of Document **DZ** Sheet **1 / 3**

INDIAN OIL CORPORATION LIMITED
MCDERMOTT TECHNOLOGY
IndianOil

thysenkruupp
©thysenkruupp Industrial Solutions (India) Private Limited
BHEL Drawing NO.: 1-11-001-U8043 REV.02
FRESH FEED FURNACE (412-H-1001)
DETAILS OF RADIANT COILS PS-25 EXP. PROJECT IND MAX FCC UNIT



Category Codes (Submission purpose)	<u>kts India / Owner/Client</u>				Acceptance Codes (Approval Code)	<u>kts India / Owner/Client</u>			
	☐ 1	For Approval				☐ 1	Approved		
	☐ 2	For Review / Comments				☐ 2	Approved for Manufacturing/ Fabrication With Comments as Marked		
	☐ 3	For Information				☐ 3	Not Approved/Resubmit		
	☐ 4	For Engineering				☐ 4	Retained for Information/Records		
	☐ 5	For Enquiry				☐ 5	Reviewed		
	☐ 6	For Order Placement				☐ 6	Reviewed as Noted/Resubmit		
	☐ 7	Final & Approved							
	☐ 8	Released for Construction				Date : / / Name :			
	Contract No.					Document ID			
66-6745				6745-PRC-012-DZ-0002-003				FOA/04	03
Store Location: Server/Share				DEM: BHARAT HEAVY ELECTRICALS LTD. HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012					
Store Location: Folder				ESC: AG FURNACE IMPROVEMENTS NDIGA, INDIA					
Store Name									
Pro. Unit	Con. Unit	TON		Group	Order No.	Type of Document	Sheet		
412		412-H-001				DZ	2 / 3		
INDIAN OIL CORPORATION LIMITED MCDERMOTT TECHNOLOGY				thyssenkrupp ©thyssenkrupp Industrial Solutions (India) Private Limited BHEL Drawing No.: 1-11-001-U8044 REV.03					
IndianOil				Description					
Date		Name		FRESH FEED FURNACE (412-H-1001) DETAILS OF RADIANT COILS PS-25 EXP. PROJECT IND MAX FCC UNIT					
Drawn	31.10.2022	A.G.F.LIS							
Prepared	31.10.2022	RAJU							
Checked	07.11.2022	S.VIJAY/A.N.V.K KISHORE							
Approved	07.11.2022	S.K.BISWAS							
Scale	1:24	Cat. Code	Acc. Code	Status					
Acc. Code									



01	03.01.2023	RAJU	04.01.2023	RAJU	04.01.2023	RAJU	REVISED AS MKD.	1
00	31.10.2022	RAJU	07.11.2022	RAJU	07.11.2022	RAJU	FIRST ISSUE	
Rev.	Date	Name	Date	Name	Date	Name	Description	Acc. Code
	Drawn/Prepared		Checked		Approved			

26	PIP 5" NPS X SCH.40 BBE, L=616				A335 Gr .P9	C		13.4
25	PIP 5" NPS X SCH.40 BBE, L=1242.6				A335 Gr .P9	C		27
24	NUT M20 HEAVY HEX.				A194 Gr.4			4
23	STUDS M20 X 95 FULL THRD.				A193 Gr.B16			64
22	GASKET 1 1/2" NPS X 300#				SPW 316L IR/OR			32
21	PIP 5" NPS X SCH.40 BBE, L=165.7				A335 Gr .P9	C		4
20	PIP 5" NPS X SCH.40 BBE, L=403.2				A335 Gr .P9	C		3.6
19	FLANGE 5" NPS X SCH. 40 X 300# WNRF				A182 Gr. F9	C		8.75
18	FLANGE 5" NPS X SCH.40 X 300# WNRF				A182 Gr. F9	C		4
17	PIP 5" NPS X SCH.40 BBE, L=923				A335 Gr .P9	C		14.6
16	NUT M20 HEAVY HEX.				A194 Gr.4			8
15	STUDS M20 X 95 FULL THRD.				A193 Gr.B16			14.6
14	GASKET 1 1/2" NPS X 300#				SPW 316L IR/OR			4
13	BLIND FLANGE 1 1/2" NPS X 300# RF				A182 Gr. F9	C		4
12	FLANGE 1 1/2" NPS X SCH.80 X 300# WNRF				A182 Gr. F9	C		96
11	WELDOLET 5" NPS X SCH.40 X 1 1/2" NPS X SCH.80				A182 Gr. F9	C		48
10	ELBOW 5" NPS X SCH. 40 X 90° SR				A234 Gr.WP9	C		12
9	RETURN BEND 5" NPS X SCH.40 X 180° SR				A234 Gr.WP9	C		2.7
8	PIPE 5" NPS X SCH.40 BBE, L=8418				A335 Gr .P9	C		12
7	ELBOW 5" NPS X SCH. 40 X 90° SR				A234 Gr.WP9	C		3.2
6	RETURN BEND 5" NPS X SCH.40 X 180° SR				A234 Gr.WP9	C		1
5	PIP 5" NPS X SCH.40 BBE, L=487				A335 Gr.P9	C		4.3
4	PIPE 5" NPS X SCH . 40 BBE, L=8418				A335 Gr .P9	C		8.6
3	SOLID FIN 1.52 THK. X 12.7 HT X 197 FINS/M, L=8218 CS FIN				A335 Gr .P9	C		10.57
2	PIPE 5" NPS X SCH . 40 BBE, L=8418				A335 Gr .P9	C		4
1	PIPE 5" NPS X SCH. 40 BBE, L=8418				A335 Gr .P9	C		447.3
VARIANT NUMBER	ITEM NUMBER	DESCRIPTION	STD	DRAWING NUMBER	ITEM NO.	MATERIAL CODE	A/C/P	UNIT WEIGHT
					VAR. NO.	MATERIAL SPECN.		QUANTITY

tkIS India / Owner/Client

☐ 1 For Approval
☒ 2 For Review / Comments
☐ 3 For Information
☐ 4 For Engineering
☐ 5 For Enquiry
☐ 6 For Order Placement
☐ 7 Final & Approved
☐ 8 Released for Construction

Category Codes (Submission purpose)

tkIS India / Owner/Client

☐ 1 Approved
☐ 2 Approved for Manufacturing/ Fabrication With Comments as Marked
☐ 3 Not Approved/Resubmit
☐ 4 Retained for Information/Records
☐ 5 Reviewed
☐ 6 Reviewed as Noted/Resubmit

Acceptance Codes (Approval Code)

Date : _/ _/ _ Name : _

Contract No. 66-6745

Document ID 6745-PRC-412-DZ-0002-004

Part Rev. F0404 01

Store Location: Server/Share

Store Location: Folder

Store Name

Pro. Unit 412 Con. Unit 412-H-001

Group

Order No.

Type of Document Sheet DZ 2 / 5

INDIAN OIL CORPORATION LIMITED

thysenkruupp

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BHEL Drawing NO.: 1-11-002-U8047 REV.01

Drawn 31.10.2022 A.G.F.I.S

Prepared 31.10.2022 RAJU

Checked 07.11.2022 S.VIJAY/A.N.V.K.KISHORE

Approved 07.11.2022 S.K.BISWAS

Date Name

Description

Acc. Code

Scale 1:32

Cat. Code

Acc. Code

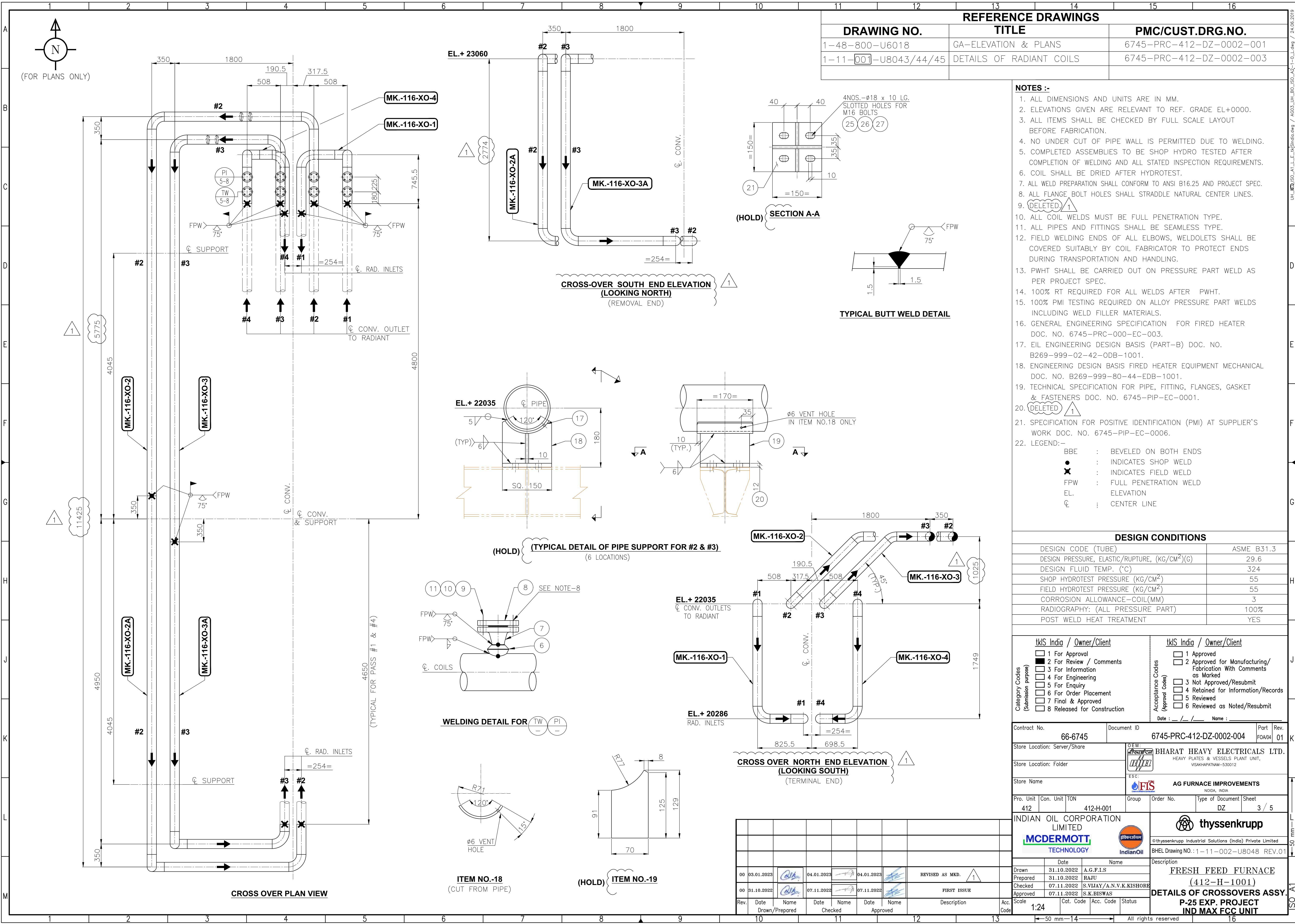
Status

FRESH FEED FURNACE (412-H-1001)

DETAILS OF CONVECTION COILS

PS-25 EXP. PROJECT IND MAX FCC UNIT

UNISO-A1-L-E-PS-25-Exp-Ind-Max-FCC-Unit / AGO3_UH_BO_ISO-A2-1-0-L-Draw / 24.06.2018



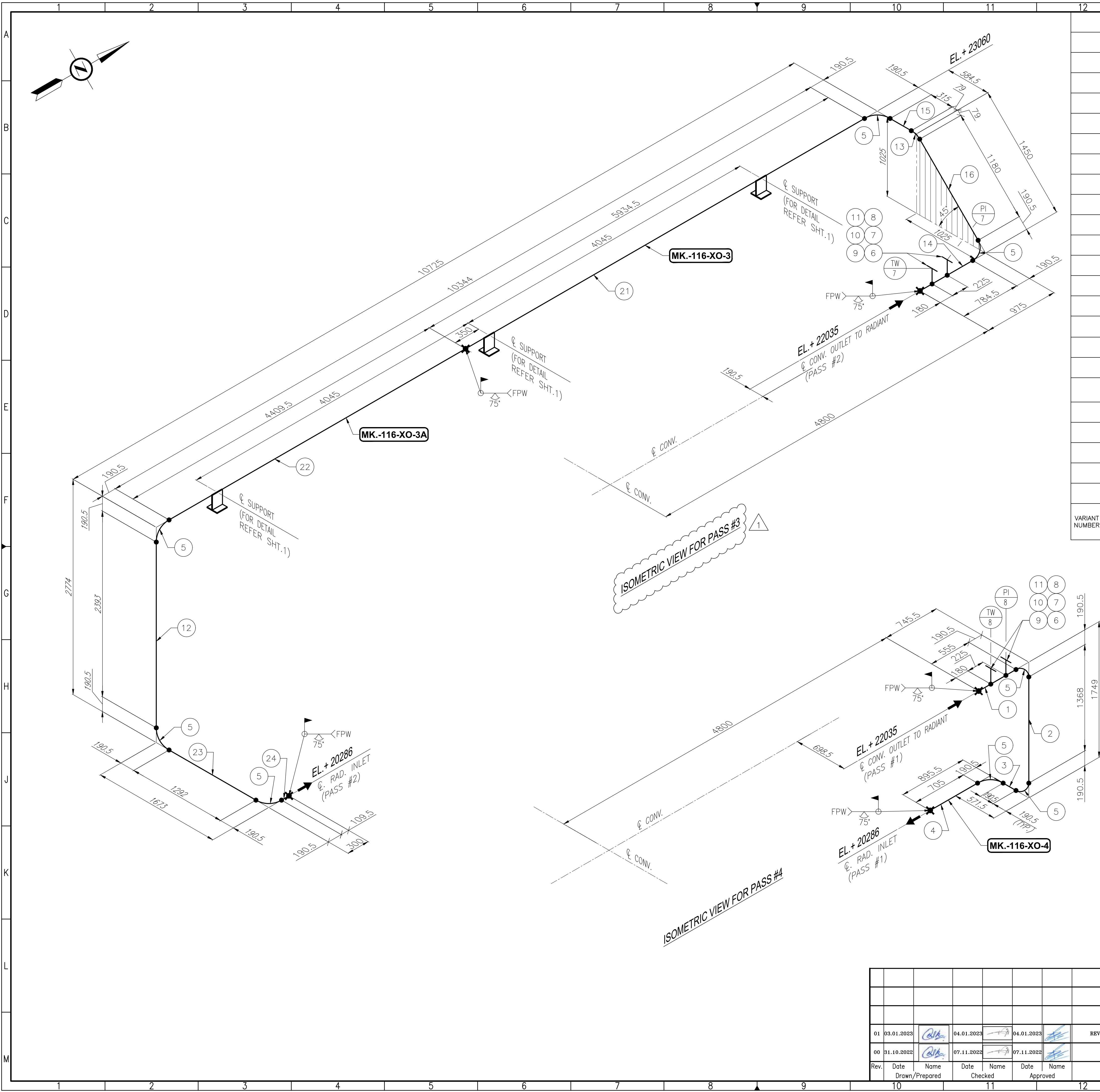
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1-48-800-U6018	GA-ELEVATION & PLANS	6745-PRC-412-DZ-0002-001
1-11-001-U8043/44/45	DETAILS OF RADIANT COILS	6745-PRC-412-DZ-0002-003

- NOTES :-**
- ALL DIMENSIONS AND UNITS ARE IN MM.
 - ELEVATIONS GIVEN ARE RELEVANT TO REF. GRADE EL+0000.
 - ALL ITEMS SHALL BE CHECKED BY FULL SCALE LAYOUT BEFORE FABRICATION.
 - NO UNDER CUT OF PIPE WALL IS PERMITTED DUE TO WELDING.
 - COMPLETED ASSEMBLIES TO BE SHOP HYDRO TESTED AFTER COMPLETION OF WELDING AND ALL STATED INSPECTION REQUIREMENTS.
 - COIL SHALL BE DRIED AFTER HYDROTEST.
 - ALL WELD PREPARATION SHALL CONFORM TO ANSI B16.25 AND PROJECT SPEC.
 - ALL FLANGE BOLT HOLES SHALL STRADDLE NATURAL CENTER LINES.
 - DELETED
 - ALL COIL WELDS MUST BE FULL PENETRATION TYPE.
 - ALL PIPES AND FITTINGS SHALL BE SEAMLESS TYPE.
 - FIELD WELDING ENDS OF ALL ELBOWS, WELDOLETS SHALL BE COVERED SUITABLY BY COIL FABRICATOR TO PROTECT ENDS DURING TRANSPORTATION AND HANDLING.
 - PWHT SHALL BE CARRIED OUT ON PRESSURE PART WELD AS PER PROJECT SPEC.
 - 100% RT REQUIRED FOR ALL WELDS AFTER PWHT.
 - 100% PMI TESTING REQUIRED ON ALLOY PRESSURE PART WELDS INCLUDING WELD FILLER MATERIALS.
 - GENERAL ENGINEERING SPECIFICATION FOR FIRED HEATER DOC. NO. 6745-PRC-000-EC-003.
 - EIL ENGINEERING DESIGN BASIS (PART-B) DOC. NO. B269-999-02-42-ODB-1001.
 - ENGINEERING DESIGN BASIS FIRED HEATER EQUIPMENT MECHANICAL DOC. NO. B269-999-80-44-EDB-1001.
 - TECHNICAL SPECIFICATION FOR PIPE, FITTING, FLANGES, GASKET & FASTENERS DOC. NO. 6745-PIP-EC-0001.
 - DELETED
 - SPECIFICATION FOR POSITIVE IDENTIFICATION (PMI) AT SUPPLIER'S WORK DOC. NO. 6745-PIP-EC-0006.
 - LEGEND:-
 - BBE : BEVELED ON BOTH ENDS
 - : INDICATES SHOP WELD
 - ✕ : INDICATES FIELD WELD
 - FPW : FULL PENETRATION WELD
 - EL. : ELEVATION
 - CL : CENTER LINE

DESIGN CONDITIONS	
DESIGN CODE (TUBE)	ASME B31.3
DESIGN PRESSURE, ELASTIC/RUPTURE, (KG/CM ²)(G)	29.6
DESIGN FLUID TEMP. (°C)	324
SHOP HYDROTEST PRESSURE (KG/CM ²)	55
FIELD HYDROTEST PRESSURE (KG/CM ²)	55
CORROSION ALLOWANCE-COIL(MM)	3
RADIOGRAPHY: (ALL PRESSURE PART)	100%
POST WELD HEAT TREATMENT	YES

tkIS India / Owner/Client	
Category Codes (Submission purpose)	Acceptance Codes (Approval Codes)
☐ 1 For Approval	☐ 1 Approved
☒ 2 For Review / Comments	☐ 2 Approved for Manufacturing/ Fabrication With Comments
☐ 3 For Information	☐ 3 Not Approved/Resubmit
☐ 4 For Engineering	☐ 4 Retained for Information/Records
☐ 5 For Enquiry	☐ 5 Reviewed
☐ 6 For Order Placement	☐ 6 Reviewed as Noted/Resubmit
☐ 7 Final & Approved	
☐ 8 Released for Construction	

Contract No.	66-6745	Document ID	6745-PRC-412-DZ-0002-004	Part Rev.	FOA04 01
Store Location:	Server/Share	REVISION	BHARAT HEAVY ELECTRICALS LTD. HEAVY PLATES & VESSELS PLANT UNIT, WISHPHATNAM-530012		
Store Location:	Folder	ESD:	AG FURNACE IMPROVEMENTS NOIDA, INDIA		
Store Name		Pro. Unit	412	Con. Unit	412-H-001
Group		Order No.		Type of Document	DZ
Sheet					3 / 5
INDIAN OIL CORPORATION LIMITED		thysenkruupp		BH&L Drawing NO.: 1-11-002-U8048 REV.01	
MCDERMOTT TECHNOLOGY		IndianOil		Description	
Date		Name		FRESH FEED FURNACE (412-H-1001)	
Drawn		A.G.F.I.S		DETAILS OF CROSSOVERS ASSY.	
Prepared		RAJU		P-25 EXP. PROJECT	
Checked		S.VIJAY/A.N.V.K.KISHORE		IND MAX FCC UNIT	
Approved		S.K.BISWAS			
Rev.	Date	Name	Date	Name	Description
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00	31.10.2022	CAJ	07.11.2022	CAJ	FIRST ISSUE

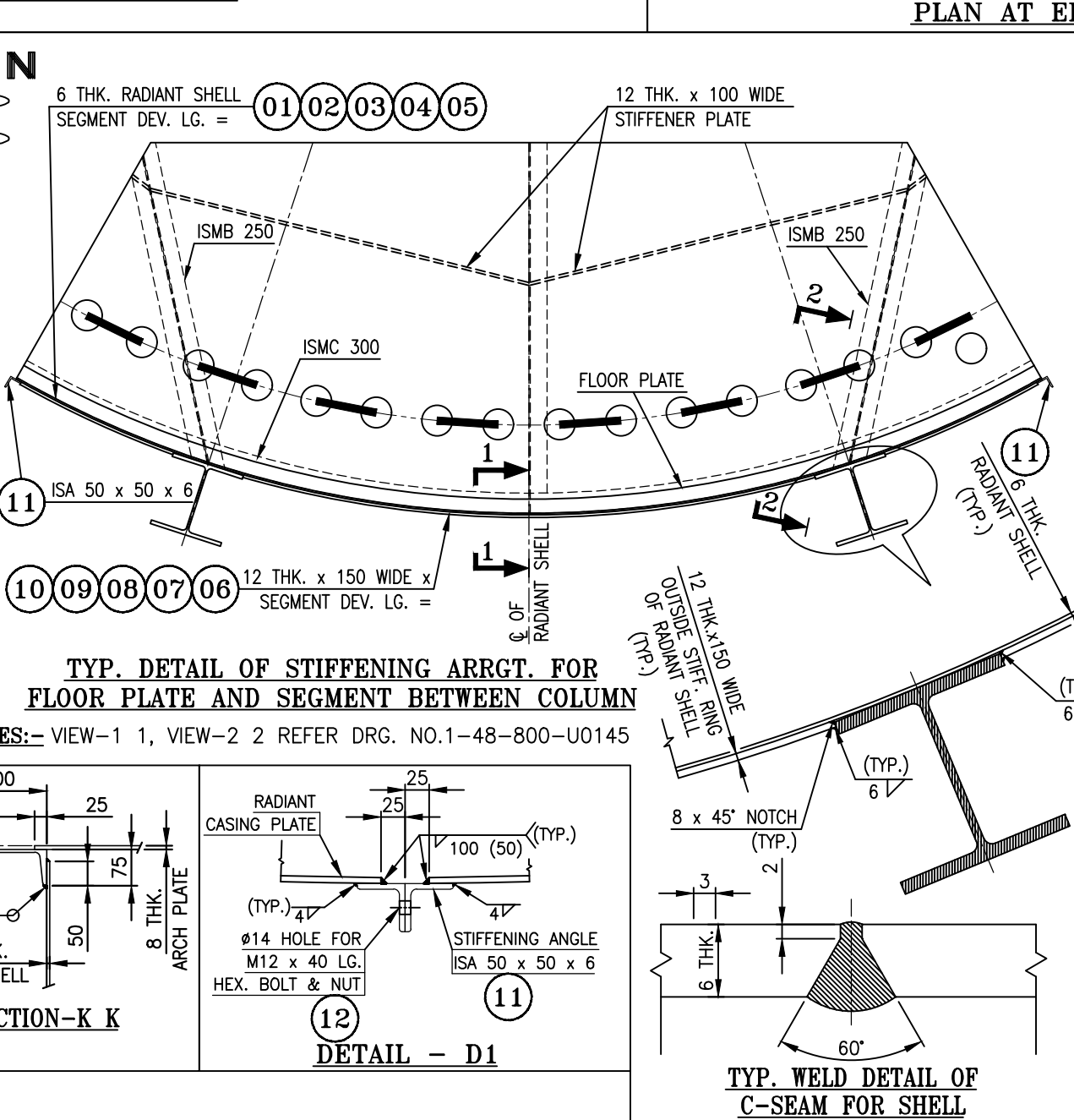
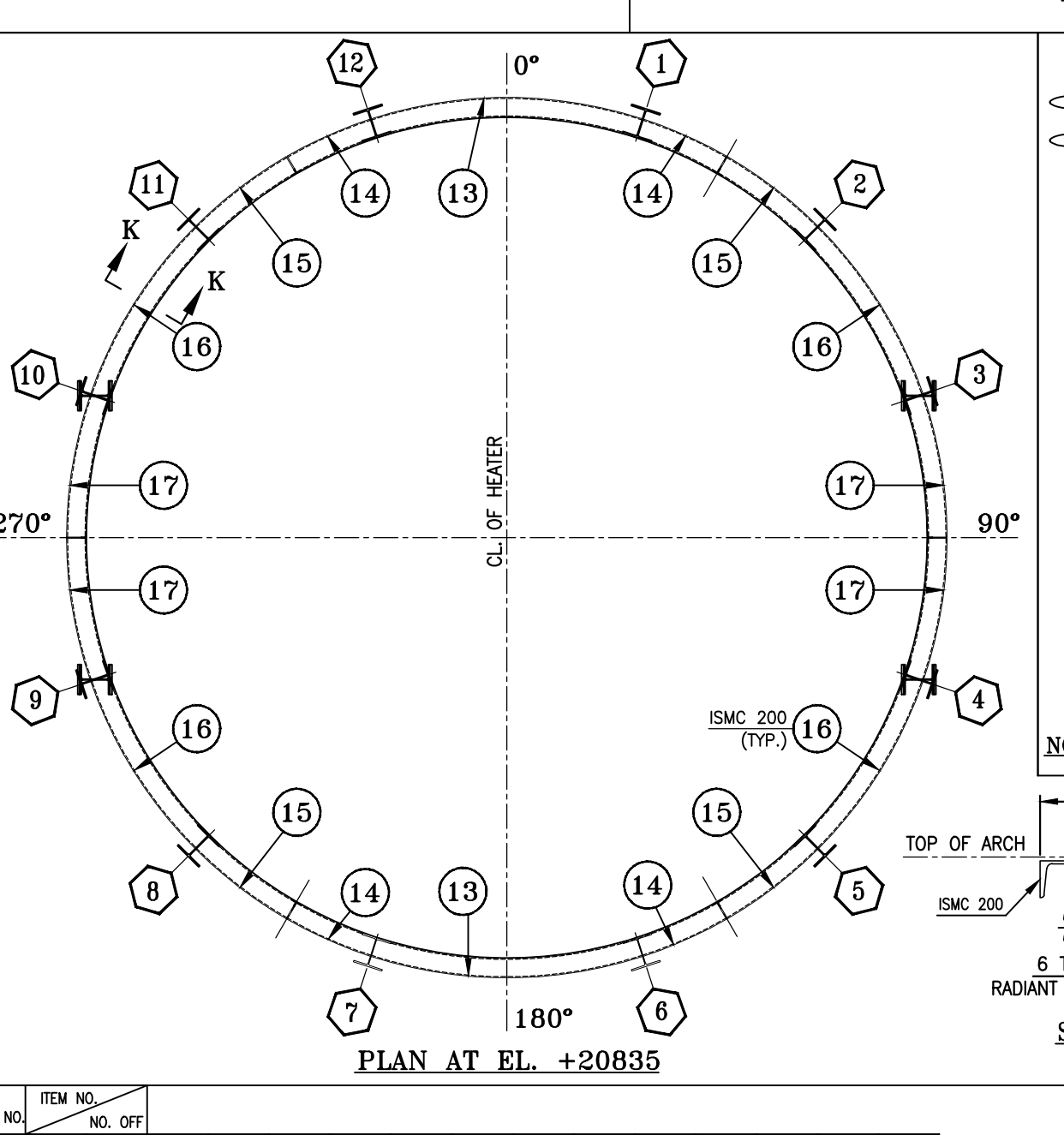
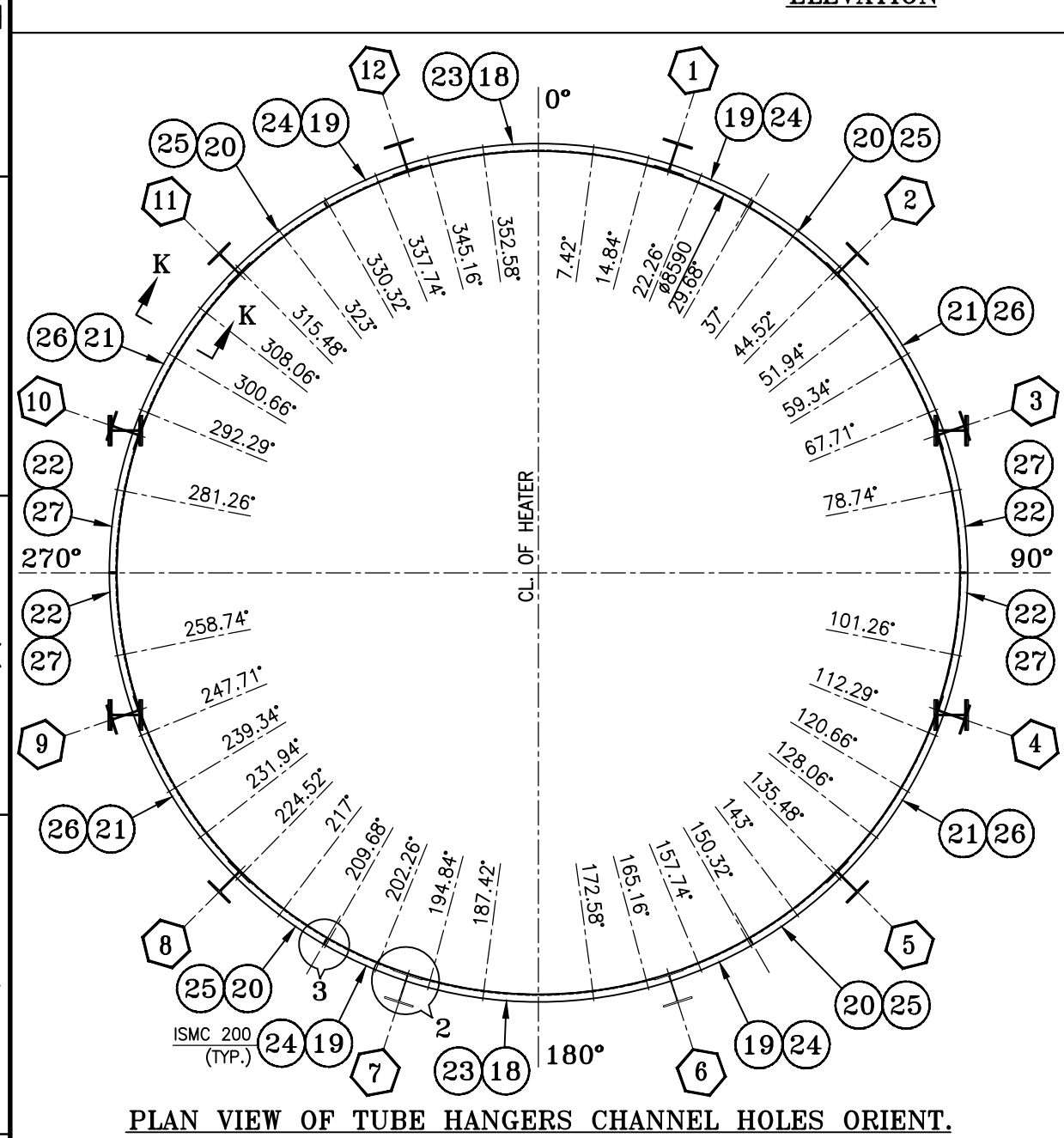
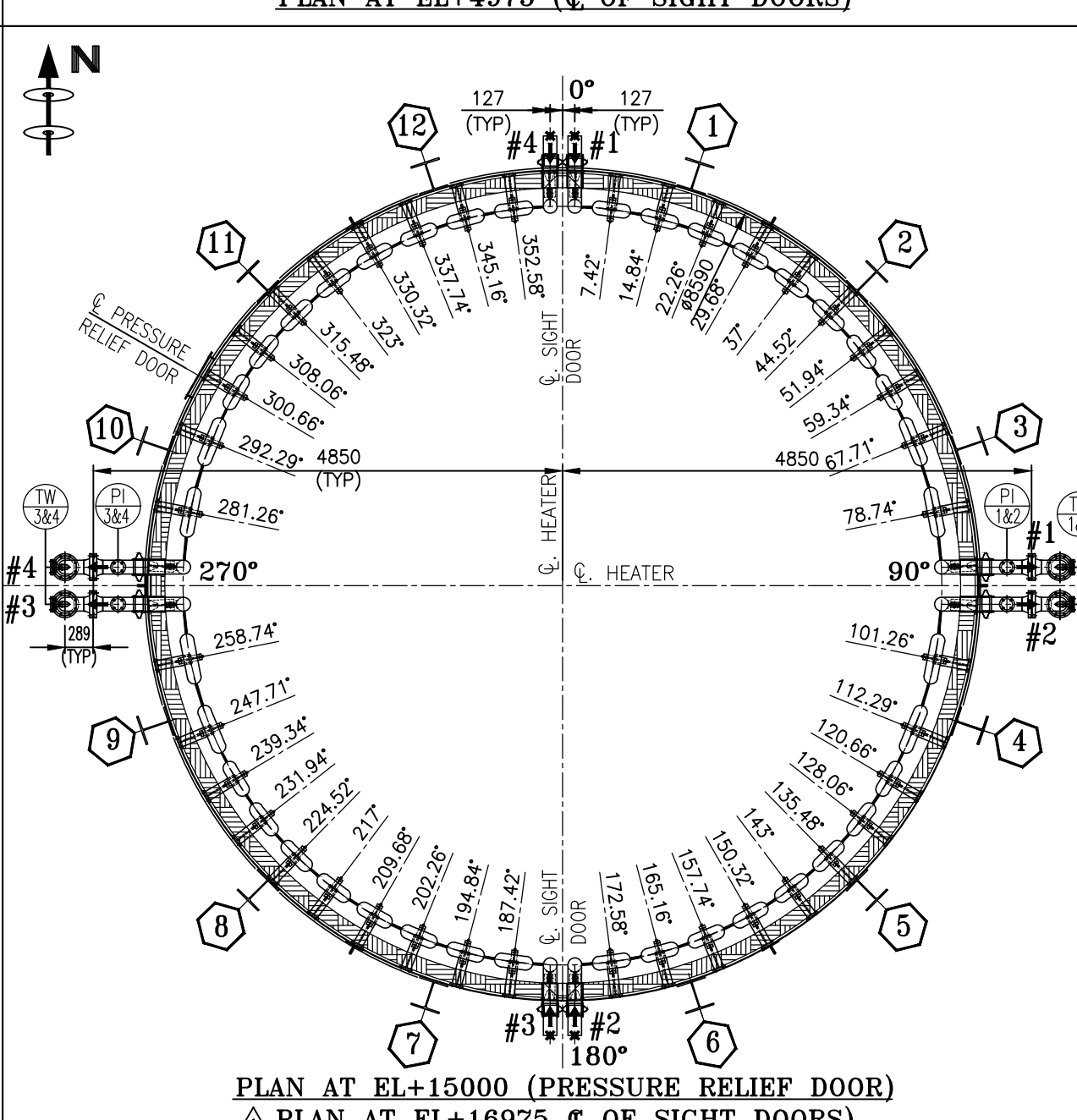
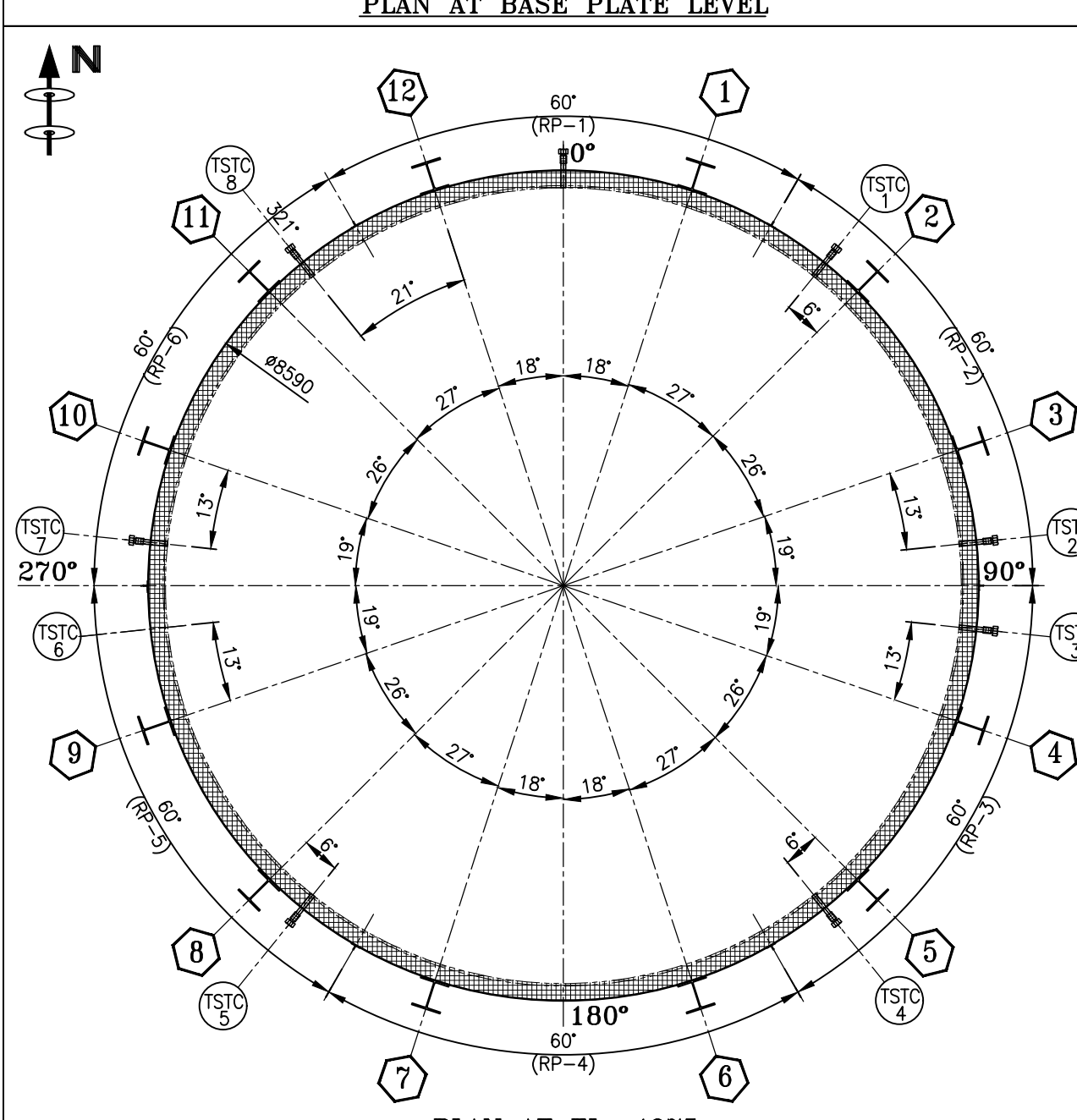
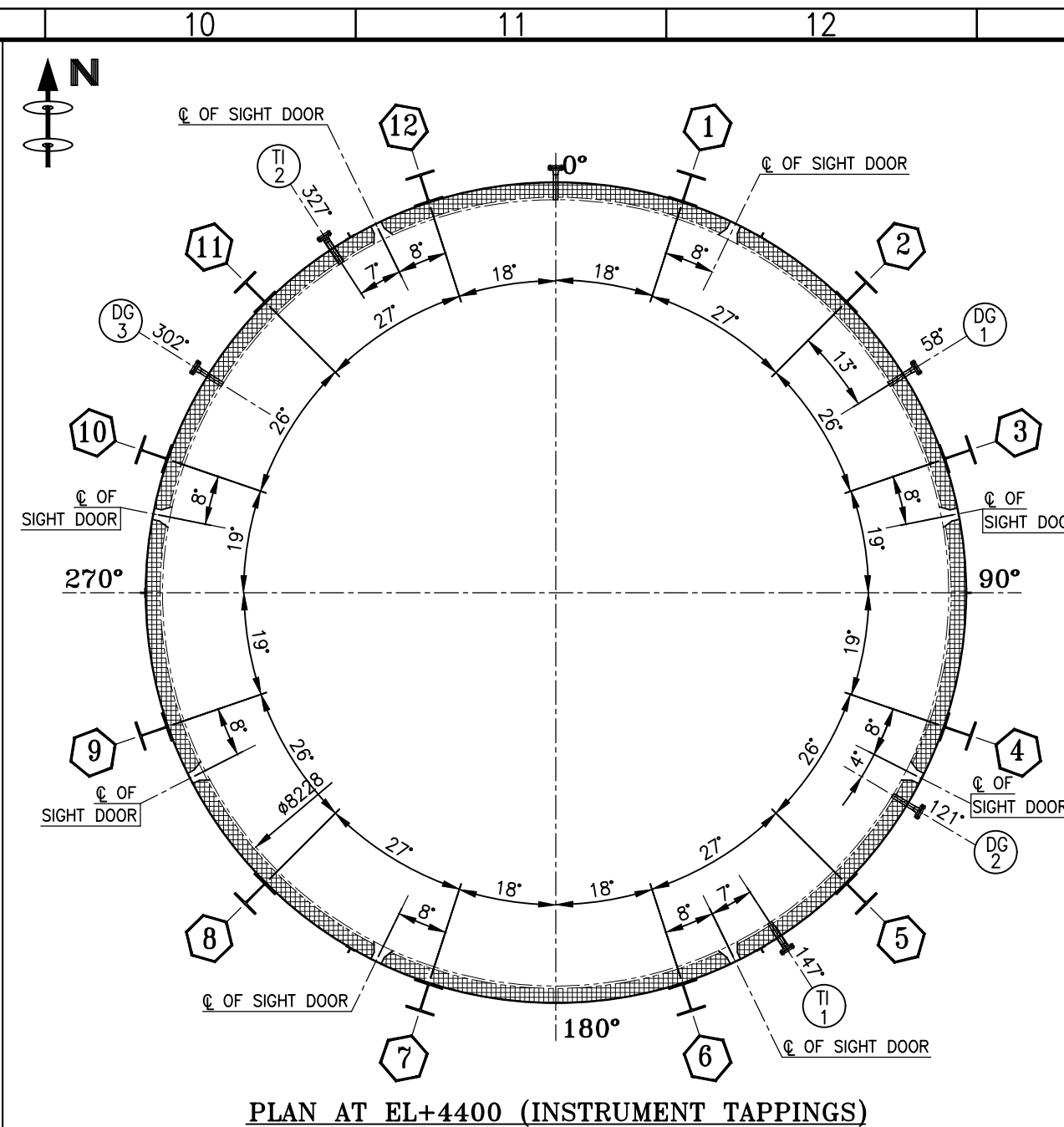
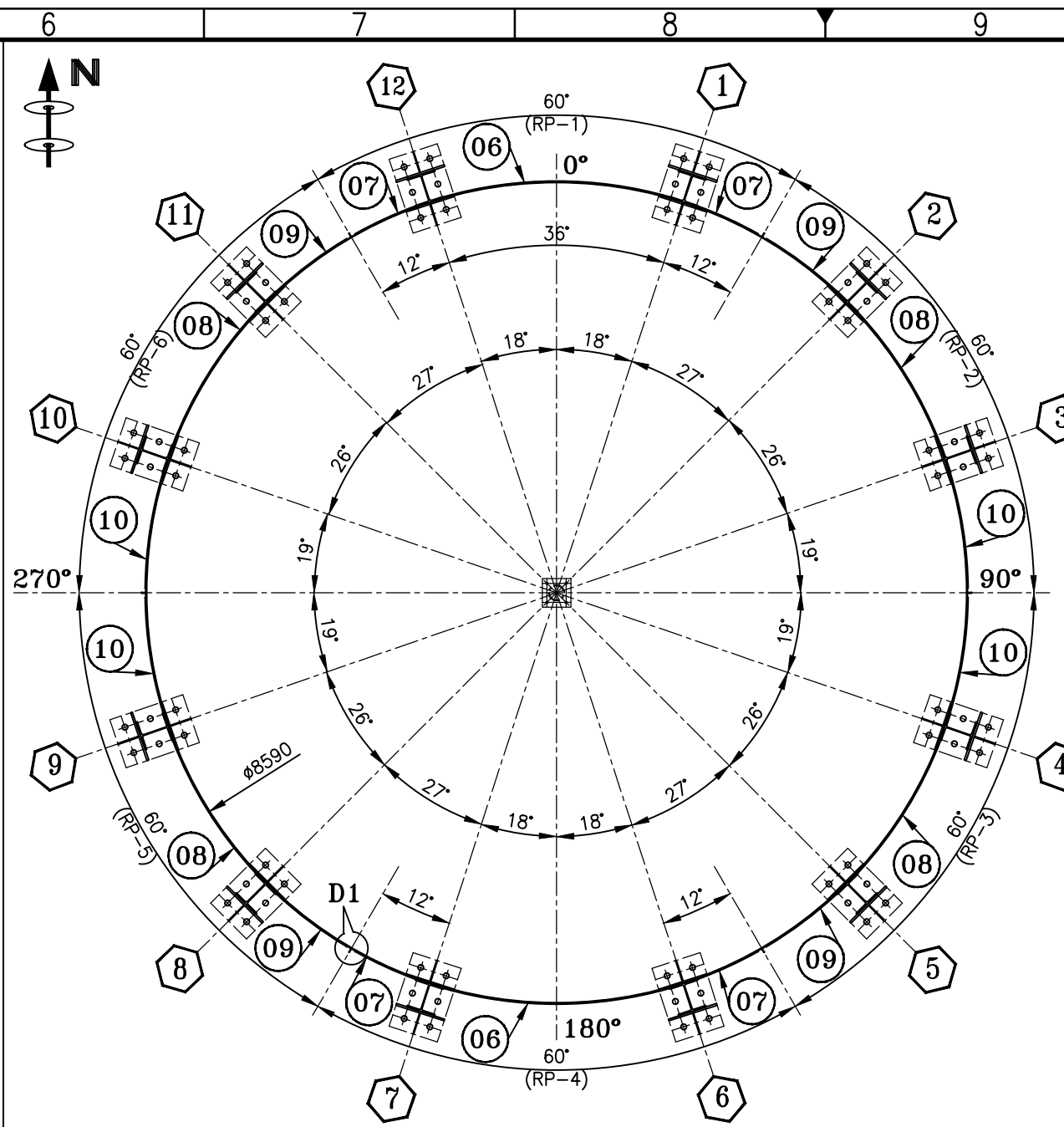
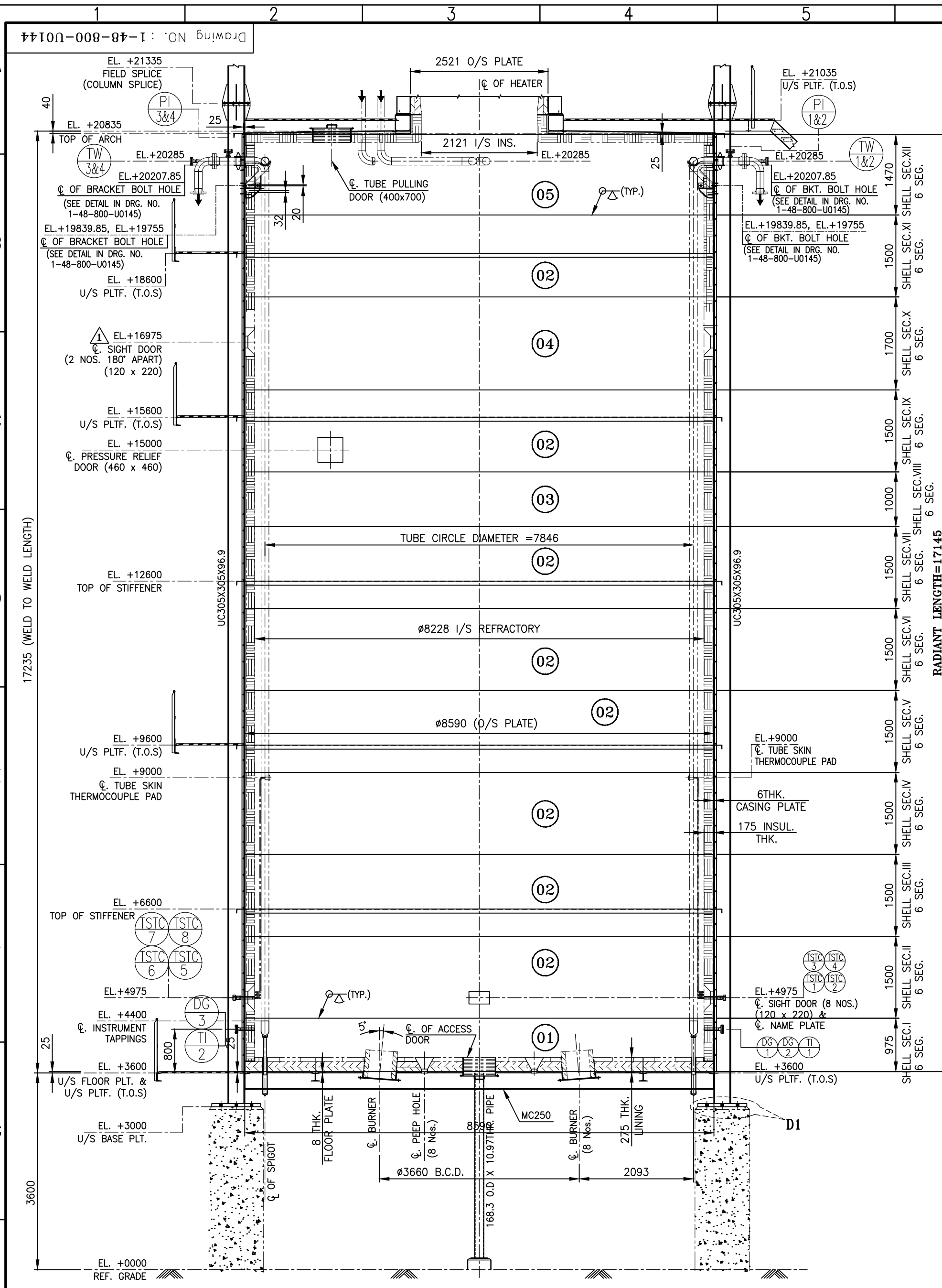


VARIANT NUMBER	ITEM NUMBER	DESCRIPTION	STD	DRAWING NUMBER	ITEM NO.	MATERIAL CODE	A/C/P	UNIT	UNIT WEIGHT
					VAR NO.	MATERIAL SPECN.		D1	QUANTITY
24	PIPE 5" NPS X SCH . 40 BBE, L=109.5						A335 Gr .P9	C	2.4
									1
									28.1
									1
23	PIPE 5" NPS X SCH . 40 BBE, L=1292						A335 Gr .P9	C	95.6
									1
									128.7
									1
22	PIPE 5" NPS X SCH . 40 BBE, L=4409.5						A335 Gr .P9	C	2.12
									3
									1.07
									0.71
21	PIPE 5" NPS X SCH . 40 BBE, L=5934.5						A335 Gr .P9	C	6
									3
									1
									0.71
20	STIFF. PLT. 150X150X12THK.						IS2062 Gr.E250		6
									3
									1
									0.71
19	STIFF. PLT. 91X150X10THK.						IS2062 Gr.E250		6
									3
									1
									0.71
18	STIFF. PLT. 70X129X10THK.						IS2062 Gr.E250		6
									3
									1
									0.71
17	PAD PLT. 5" NPS X SCH.40 BBE, L=170						A335 Gr .P9	C	3
									25.7
									1
									6.8
16	PIPE 5" NPS X SCH . 40 BBE, L=315						A335 Gr .P9	C	1
									17.02
									1
									3.2
15	PIPE 5" NPS X SCH . 40 BBE, L=784.5						A335 Gr .P9	C	1
									3.2
									1
									0.71
14	ELBOW 5" NPS X SCH.40 X 45						A234 Gr.WP9	C	1
									52
									1
									0.71
13	PIPE 5" NPS X SCH . 40 BBE, L=2393						A335 Gr .P9	C	1
									32
									16
									4
12	GASKET 1 1/2" NPS X 300#						SPW 316L IR/OR		2.7
									4
									3.2
									4
11	BLIND FLANGE 1 1/2" NPS X 300# RF						A182 Gr. F9	C	0.5
									4
									6.5
									8
10	FLANGE 1 1/2" NPS X SCH.80 X 300# RFWN						A182 Gr. F9	C	15.3
									1
									4.1
									1
9	Weldolet 5" NPS X SCH.40 X 1 1/2" NPS SCH.80						A335 Gr .P9	C	29.7
									1
									12.04
									1
8	ELBOW 5" NPS X SCH . 40 X 90° LR						A234 Gr. WP9	C	1
									15.3
									1
									4.1
7	PIPE 5" NPS X SCH . 40 BBE, L=705						A335 Gr .P9	C	1
									29.7
									1
									12.04
6	PIPE 5" NPS X SCH . 40 BBE, L=190.5						A335 Gr .P9	C	1
									1
									12.04
									1
5	PIPE 5" NPS X SCH . 40 BBE, L=1368						A335 Gr .P9	C	1
									1
									12.04
									1
4	PIPE 5" NPS X SCH . 40 BBE, L=555						A335 Gr .P9	C	1
									1
									12.04
									1
3	PIPE 5" NPS X SCH . 40 BBE, L=190.5						A335 Gr .P9	C	1
									1
									12.04
									1
2	PIPE 5" NPS X SCH . 40 BBE, L=1368						A335 Gr .P9	C	1
									1
									12.04
									1
1	PIPE 5" NPS X SCH . 40 BBE, L=555						A335 Gr .P9	C	1
									1
									12.04
									1
VARIANT NUMBER	ITEM NUMBER	DESCRIPTION	STD	DRAWING NUMBER	ITEM NO.	MATERIAL CODE	A/C/P	UNIT	UNIT WEIGHT
					VAR NO.	MATERIAL SPECN.		D1	QUANTITY

tkIS India / Owner/Client		tkIS India / Owner/Client	
☐ 1 For Approval ☒ 2 For Review / Comments ☐ 3 For Information ☐ 4 For Engineering ☐ 5 For Enquiry ☐ 6 For Order Placement ☐ 7 Final & Approved ☐ 8 Released for Construction		☐ 1 Approved ☐ 2 Approved for Manufacturing/ Fabrication With Comments as Marked ☐ 3 Not Approved/Resubmit ☐ 4 Retained for Information/Records ☐ 5 Reviewed ☐ 6 Reviewed as Noted/Resubmit	
Contract No. 66-6745		Document ID 6745-PRC-412-DZ-0002-004	
Store Location: Server/Share		BHEM BHARAT HEAVY ELECTRICALS LTD. HEAVY PLATES & VESSELS PLANT UNIT, WISKHAPATNAM-530012	
Store Location: Folder		AG FURNACE IMPROVEMENTS NOIDA, INDIA	
Store Name		INDIAN OIL CORPORATION LIMITED	
Pro. Unit 412		Con. Unit 412-H-001	
Group		Order No. DZ	
Type of Document Sheet 5 / 5		thysenkrupp	
INDIAN OIL CORPORATION LIMITED		©thysenkrupp Industrial Solutions (India) Private Limited	
MCDERMOTT TECHNOLOGY		BHEL Drawing NO.: 1-11-002-U8050 REV.01	
Date 31.10.2022		Name A.G.F.I.S	
Prepared 31.10.2022		RAJU	
Checked 07.11.2022		S.VIJAY/A.N.V.K.KISHOR	
Approved 07.11.2022		S.K.BISWAS	
Description REVISED AS MKD.		Description FRESH FEED FURNACE (412-H-1001)	
FIRST ISSUE		DETAILS OF CROSSOVERS-ISO-2 P-25 EXP. PROJECT IND MAX FCC UNIT	
Rev.	Date	Name	Description
01	03.01.2023	RAJU	REVISED AS MKD.
00	31.10.2022	RAJU	FIRST ISSUE
Rev.	Date	Name	Description
01	03.01.2023	RAJU	REVISED AS MKD.
00	31.10.2022	RAJU	FIRST ISSUE

**SUPPLY OF 1 No. BALANCED DRAFT FIRED HEATER OF 22.66 (MkCal/h) HEAT DUTY FOR
INDMAX FCCU UNIT OF IOCL PANIPAT REFINERY (P-25 PROJECT)
HEATER TAG No. (412-H-1001) - FRESH FEED FURNACE**

Sl.No.	Reference				M/s. tkIS Query	BHEL Reply
	Doc./Dwg No.	Pg.No.	Cl.No.	Reference Clause / Subject		
1	1-11-002-U8046 / 6745-PRC-412-DZ-0002-004	sht 1			Check sequence. It should be reverse (#4, #3, #2, #1)	Sequence has been checked and found ok. For clarity, sequence has been marked on other side. The drawing is prepared in third angle projection.
2	1-11-002-U8046 / 6745-PRC-412-DZ-0002-004	sht 1			Referred Specification is not a part of Tender Specification provided to BHEL. Hence, BHEL to kindly remove the reference	Note deleted.
3	1-11-002-U8046 / 6745-PRC-412-DZ-0002-004	sht 3			Referred Specification is not a part of Tender Specification provided to BHEL. Hence, BHEL to kindly remove the reference	Note deleted.



BRACKET REF. ELEV. & ORIENT.			
REFER. ELEV.	REFER. ORIENT.	REFER. ELEV.	REFER. ORIENT.
17754.85	7.42°	17754.85	187.42°
17691.35	14.84°	17691.35	194.84°
17691.35	22.26°	17691.35	202.26°
17691.35	29.68°	17691.35	209.68°
17691.35	37°	17691.35	217°
17691.35	44.52°	17691.35	224.52°
17691.35	51.94°	17691.35	231.94°
17691.35	59.34°	17691.35	239.34°
17691.35	67.71°	17691.35	247.71°
17691.35	78.74°	17691.35	258.74°
17691.35	101.26°	17691.35	281.26°
17691.35	112.29°	17691.35	292.29°
17691.35	120.66°	17691.35	300.66°
17754.85	128.06°	17754.85	308.06°
17754.85	135.48°	17754.85	315.48°
17754.85	143°	17754.85	323°
17754.85	150.32°	17754.85	330.32°
17754.85	157.74°	17754.85	337.74°
17754.85	165.16°	17754.85	345.16°
17754.85	172.58°	17754.85	352.58°

DETAIL OF RADIANT SEGMENT			
ITEM NO.	DEV. LG.	QTY.	SHELL COURSE NO.
01	4445	1	RP-1
02	4445	1	RP-2
03	4445	1	RP-3
04	4445	1	RP-4
05	4445	1	RP-5
06	2397	2	RP-6
07	698	4	
08	1646	4	
09	923	4	
10	1224	4	

ITEM NO.		NO. OFF.	
001	01	02	03
002	01	02	03
003	01	02	03
004	01	02	03
005	01	02	03
006	01	02	03
007	01	02	03

ITEM NO.				NO. OFF.			
27	RADIANT TUBE HANGER	ISM200	1426				
28	RADIANT TUBE HANGER	ISM200	1956				
25	RADIANT TUBE HANGER	ISM200	1123				
24	RADIANT TUBE HANGER	ISM200	897				
23	RADIANT TUBE HANGER	ISM200	2712				
22	RADIANT TUBE HANGER	ISM200	1426				
21	RADIANT TUBE HANGER	ISM200	1956				
20	RADIANT TUBE HANGER	ISM200	1123				
19	RADIANT TUBE HANGER	ISM200	897				
18	RADIANT TUBE HANGER	ISM200	2712				
17	RADIANT TOP ARCH PLATE	ISM200	1446				
16	RADIANT TOP ARCH PLATE	ISM200	1984				
15	RADIANT TOP ARCH PLATE	ISM200	1140				
14	RADIANT TOP ARCH PLATE	ISM200	910				
13	RADIANT TOP ARCH PLATE	ISM200	2751				
12	HEX BOLT WITH NUT	M12 x 175P	4015				
11	ISA 50 x 50 x 6	17145					
10	RADIANT OUTSIDE	PLATE 12	150	1224			
09	RADIANT OUTSIDE	PLATE 12	150	923			
08	RADIANT OUTSIDE	PLATE 12	150	1646			
07	RADIANT OUTSIDE	PLATE 12	150	898			
06	RADIANT OUTSIDE	PLATE 12	150	2397			
05	RADIANT OUTSIDE	PLATE 6	1430	4445			
04	RADIANT OUTSIDE	PLATE 6	1700	4445			
03	RADIANT OUTSIDE	PLATE 6	1000	4445			
02	RADIANT OUTSIDE	PLATE 6	1500	4445			
01	RADIANT OUTSIDE	PLATE 6	975	4445			

Category Codes (Submission purpose)

☐ 1 For Approval
☐ 2 For Review / Comments
☐ 3 For Information
☐ 4 For Engineering
☐ 5 For Enquiry
☐ 6 For Order Placement
☐ 7 Final & Approved
☐ 8 Released for Construction

Acceptance Codes (Approval Codes)

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☐ 2 Approved for Manufacturing / Fabrication With Comments as Marked
☐ 3 Not Approved/Resubmit
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☐ 6 Reviewed as Noted/Resubmit

Contract No. 66-6745

Document ID 6745-PRC-412-DZ-0002-038

Part Rev. FOA04 A

Store Location: Server/Share

Store Location: Folder

Store Name

Pro. Unit 412

Con. Unit 412-H-001

Group

Order No.

Type of Document Sheet DZ

INDIAN OIL CORPORATION LIMITED

MCDERMOTT TECHNOLOGY

IndianOil

thysenkrupp

thysenkrupp Industrial Solutions (India) Private Limited

BHEL Drawing NO. : 1-48-800-U0144

REV. 1

Drawn 27-04-2023 BHEL

Prepared 27-04-2023 N. PRAKASA RAO

Checked 27-04-2023 S. KUMAR MANIKYAM

Approved 27-04-2023 PK SAHOO

Scale 1 : 50, N.T.S.

Cat. Code

Acc. Code

Status

FABRICATION DETAILS OF RADIANT SECTION

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PLAN VIEW OF FLOOR PALTE

NOTE : THE MEMBERS ARE TO BE RELEASED BY STRUCTURAL SECTION OF BHEL & SAME WILL BE WELDED TO FLOOR PLATE AS

THIS DRAWING. DETAIL OF OPENINGS IN FLOOR PLATE

▲ N ELEVATION 150

SIDE VIEW

		2490	1
--	--	------	---

CHANNEL 100 TYP. 2

2755

280 STIFF PLATE

ITEM NO. 05 ITEM NO. 06

1 NO. REQD. & 1 NO. OPP. HAND

1	2	3	4
---	---	---	---

5	6	7	8
---	---	---	---

DETAIL OF RETAINER PLATES AT ARCH

9	10	11	
---	----	----	--

DU NO.	ITEM NO. NO. OFF.
018	01 1
019	02 2
020	03 11
021	04 1
022	05 2
023	06 2
024	07 2
025	08 2
026	09 1
027	10 2
028	11 1
029	12 4
030	13 3
031	14 4
032	15 8
033	16 2 17 72 18 6 26 3
034	16 2 17 72 18 6 26 3
035	19 2
036	20 2
037	21 2
038	22 2
039	23 2
040	24 2
041	25 4
042	27 1 28 1

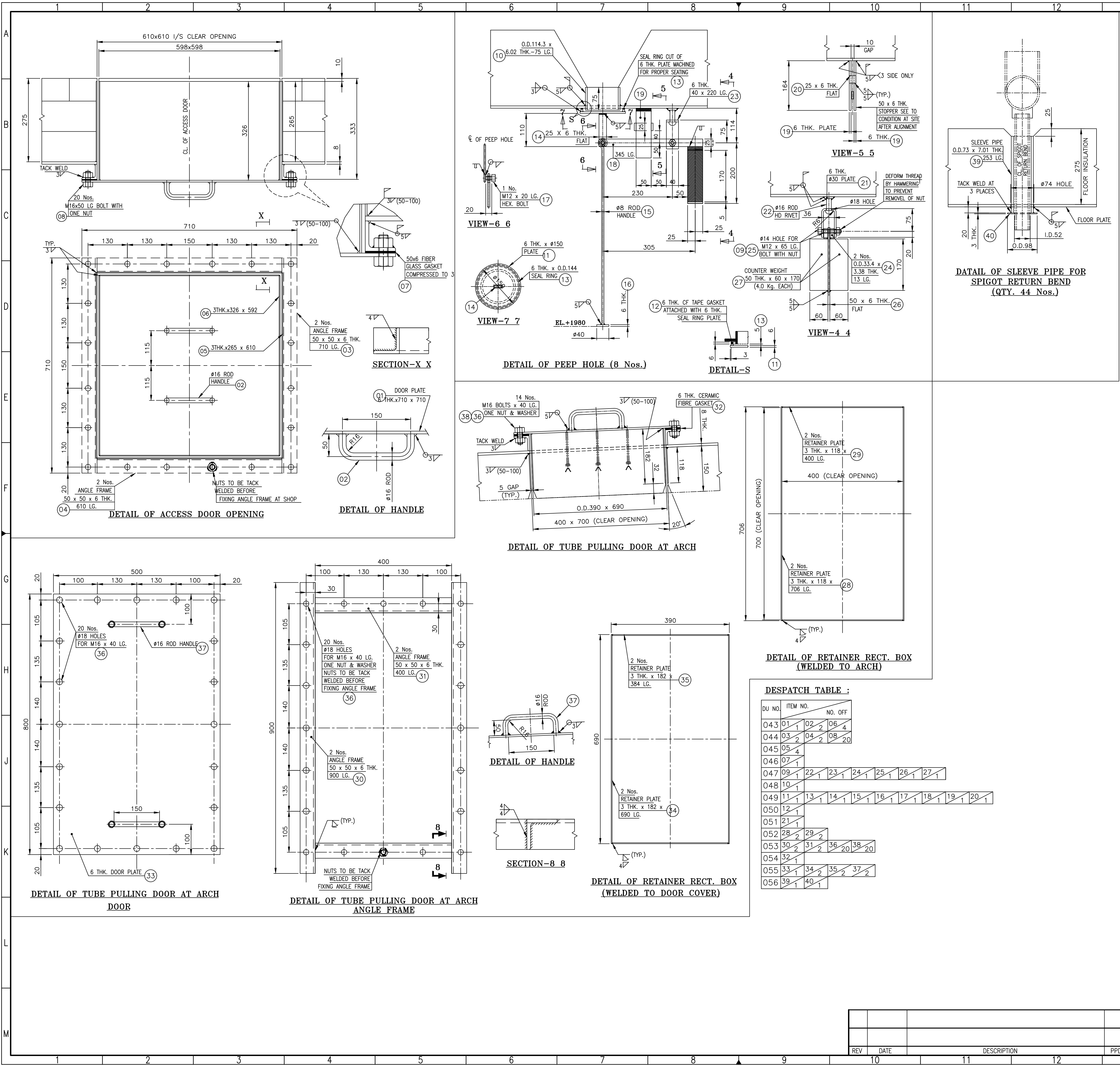
[illegible]

	CUST NO.7935
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NOTES:-

Category Codes (Submission purpose)	<u>tkIS India / Owner/Client</u>	<u>tkIS India / Owner/Client</u>
	☐ 1 For Approval ☒ 2 For Review / Comments ☐ 3 For Information ☐ 4 For Engineering ☐ 5 For Enquiry ☐ 6 For Order Placement ☐ 7 Final & Approved ☐ 8 Released for Construction	☐ 1 Approved ☐ 2 Approved for Manufacturing/ Fabrication With Comments as Marked ☐ 3 Not Approved/Resubmit ☐ 4 Retained for Information/Records ☐ 5 Reviewed ☐ 6 Reviewed as Noted/Resubmit
	Date : / / Name :	

Contract No.			Document ID			Part			Rev.		
66-6745			6745-PRC-412-DZ-0002-038			FOA/04			A		
Store Location: Server/Share						 BHARAT HEAVY ELECTRICALS LTD. HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012					
Store Location: Folder						 AG FURNACE IMPROVEMENTS NOIDA, INDIA					
Store Name						 AG FURNACE IMPROVEMENTS NOIDA, INDIA					
Pro. Unit		Con. Unit		TON		Group		Order No.		Sheet	
412				412-H-001						DZ	
INDIAN OIL CORPORATION LIMITED						 thysenkrupp					
											
						© thysenkrupp Industrial Solutions (India) Private Limited					
						BHEL Drawing NO. : 1-48-800-U0146 REV. 0					
Date		Name				Description					
---		---				FAB. DETAILS OF FLOOR PLATE AND ARCH PLATE					
Prepared		26-04-2023		K K RAO							
Checked		26-04-2023		S KUMAR MANIKYAM							
Approved		26-04-2023		PK SAHOO							
Scale		Cat. Code		Acc. Code		Status					



40	WASHER FOR SLEEVE PIPE	O D 88 x ID 52 x 3THK				156030540000	0.13	0.13	44	5.72	B
						SA 240 TP 310					
						SA172 310 / SA173 TP 310H	11.41	3.17	44	139.57	
						15647310000 IS 2016	0.011	0.011	20	0.220	
39	SLEEVE PIPE FOR SPIGOT RETURN	O D 73 x 7.01 THK	278			15675000000	1.58	0.427	2	0.855	C
38	WASHER FOR TUBE PULLING DOOR	A18				IS 2062 GR A					
37	HANDLE FOR TUBE PULLING DOOR	Ø16	270			15601760000	0.124	0.124	20	2.48	
36	BOLT & NUT FOR TUBE PULLING DOOR	M16 x 40 LG.				IS 1367 CL 4 614.0					
35	PLATE FOR TUBE PULLING DOOR	PLATE 3	384	182		156030540000	23.55	1.65	2	3.29	D
34	PLATE FOR TUBE PULLING DOOR	PLATE 3	690	182		SA 240 TP 310	23.55	2.96	2	5.91	
33	PLATE FOR TUBE PULLING DOOR	PLATE 6	800	500		150110370000 IS 2062 E250A (FE+10W)	47.1	18.84	1	18.84	
32	C.F GASKET FOR TUBE PULLING DOOR	6 THK. C.F GASKET	2820	50		15000170000 O/TATE GASKET SUITABLE FOR 600 TUBE WITH RAKT RESISTANT AGAINST SUITABLE PORTTEMP 150P	0.981	0.981	1	0.981	
31	ANGLE FOR TUBE PULLING DOOR	ISA 50x50x6	400			150110370000	4.5	1.80	2	3.60	E
30	ANGLE FOR TUBE PULLING DOOR	ISA 50x50x6	900			IS 2062 E250A (FE+10W)	4.5	4.05	2	8.10	
29	PLATE FOR TUBE PULLING DOOR	PLATE 3	400	118		156030540000 SA 240 TP 310	23.55	1.11	2	2.22	
28	PLATE FOR TUBE PULLING DOOR	PLATE 3	706	118		15603000000 SA 240 TP 310	23.55	1.96	2	3.92	
27	PLATE FOR PEEP HOLE	PLATE 50	170	60		IS 2062 E250B (FE+10W)	392.5	4.00	16	64.00	F
26	PLATE FOR PEEP HOLE	PLATE 6	188	50		IS 2062 E250A (FE+10W)	47.10	0.44	6	3.54	
25	BOLT FOR PEEP HOLE	M12 x 65 LG.				15001740000 IS 1367 CL 4 6	0.072	0.072	6	0.576	
24	PIPE FOR PEEP HOLE	O D 33.4 x 3.38 THK.	13			150110370000 150624110000 SA 106 GR B	2.5	0.03	16	0.52	
23	PLATE FOR PEEP HOLE	PLATE 6	220	40		IS 2062 E350BR	47.10	0.41	6	3.32	G
22	RIVET FOR PEEP HOLE	Ø16 HD RIVET	39			150053910000 IS 2068	0.068	0.068	6	0.544	
21	PLATE FOR PEEP HOLE	PLATE 6	Ø30			150110370000 IS 2062 E350BR	47.10	0.03	6	0.24	
20	PLATE FOR PEEP HOLE	PLATE 6	25	25		150110370000 IS 2062 E350BR	47.10	0.03	16	0.47	
19	PLATE FOR PEEP HOLE	PLATE 6	164	50		150110370000 IS 2062 E350BR	47.10	0.39	16	6.18	H
18	PLATE FOR PEEP HOLE	PLATE 6	345	25		150110370000 IS 2062 E350BR	47.10	0.41	6	3.25	
17	BOLT FOR PEEP HOLE	M12 x 20 LG.				15001740000 IS 1367 CL 4 6	0.064	0.064	6	0.512	
16	PLATE FOR PEEP HOLE	PLATE 6	Ø40			150110370000 IS 2062 E350BR	47.1	0.06	6	0.48	
15	HANDLE FOR PEEP HOLE	Ø8	1300			15675000000 IS 2062 GR A	0.39	0.51	6	4.08	I
14	PLATE FOR PEEP HOLE	PLATE 6	110	25		150110370000	47.10	0.13	6	1.04	
13	SEAL RING FOR PEEP HOLE	OD 144 x 6 THK	5 LG.			IS 2062 E350BR 150110370000 IS 2062 E350BR	0.100	0.100	6	0.60	
12	C.F GASKET FOR PEEP HOLE	6 THK. C.F GASKET	OD 144 / ID 132			15000170000 O/F GASKET SUITABLE FOR 600P TUBE WITH AKCHES/SUITABLE PORTTEMP 150P	0.020	0.020	6	0.160	
11	PLATE FOR PEEP HOLE	PLATE 6	Ø150			150110370000 IS 2062 E250A (FE+10W)	47.1	0.83	6	6.64	J
10	PIPE FOR PEEP HOLE	O.D.114.3 x 6.02 THK.	75			151821580000 SA 106 GR B	16.07	1.21	8	9.64	
09	NUT FOR PEEP HOLE	M12				15000045491 IS 1367 CL 4 6	0.017	0.017	6	0.14	
08	BOLT & NUT FOR ACCESS DOOR	M16 x 50 LG.				15001750000 IS 1367 CL 4 614.0	0.124	0.124	20	2.48	
07	FIBRE GLASS GASKET FOR ACCESS DOOR	6 THK x 50 W	2640			15000170000 FIBRE GLASS GASKET	0.020	0.020	1	0.020	K
06	PLATE FOR ACCESS DOOR	PLATE 3	326	992		156030540000	23.70	4.57	4	18.36	
05	PLATE FOR ACCESS DOOR	PLATE 3	265	610		15602000000 SA 240 TP 310	23.70	3.83	4	15.32	
04	ANGLE FOR ACCESS DOOR	ISA 50x50x6	610			150110360000 IS 2062 E250A (FE+10W)	4.5	2.75	2	5.49	
03	ANGLE FOR ACCESS DOOR	ISA 50x50x6	710			150110360000 IS 2062 E250A (FE+10W)	4.5	3.20	2	6.39	L
02	HANDLE FOR ACCESS DOOR	Ø16	229			15675000000 IS 2062 GR A	1.58	0.36	2	0.72	
01	COVER PLATE FOR ACCESS DOOR	PLATE 6	710	710		150110950000 SA 240 TP 310	23.70	11.95	1	11.95	
						MATERIAL CODE MATERIAL SPECN	UNIT WEIGHT	WT. PER NO.	QTY.	TOTAL WT.	
GRAND TOTAL:										363.842	

CUST NO.7935

NOTES:-

Category Codes (Submission purpose)

1 For Approval

2 For Review / Comments

3 For Information

4 For Engineering

5 For Enquiry

6 For Order Placement

7 Final & Approved

8 Released for Construction

Acceptance Codes (Approval Codes)

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2 Approved for Manufacturing / Fabrication With Comments as Marked

3 Not Approved/Resubmit

4 Retained for Information/Records

5 Reviewed

6 Reviewed as Noted/Resubmit

Contract No. 66-6745

Document ID 6745-PRC-412-DZ-0002-038

Part Rev. FOA04 A

Store Location: Server/Share

Store Location: Folder

Store Name

Pro. Unit 412 Con. Unit 412-H-001

Group Order No. 412

Type of Document Sheet DZ

INDIAN OIL CORPORATION LIMITED

MCDERMOTT TECHNOLOGY

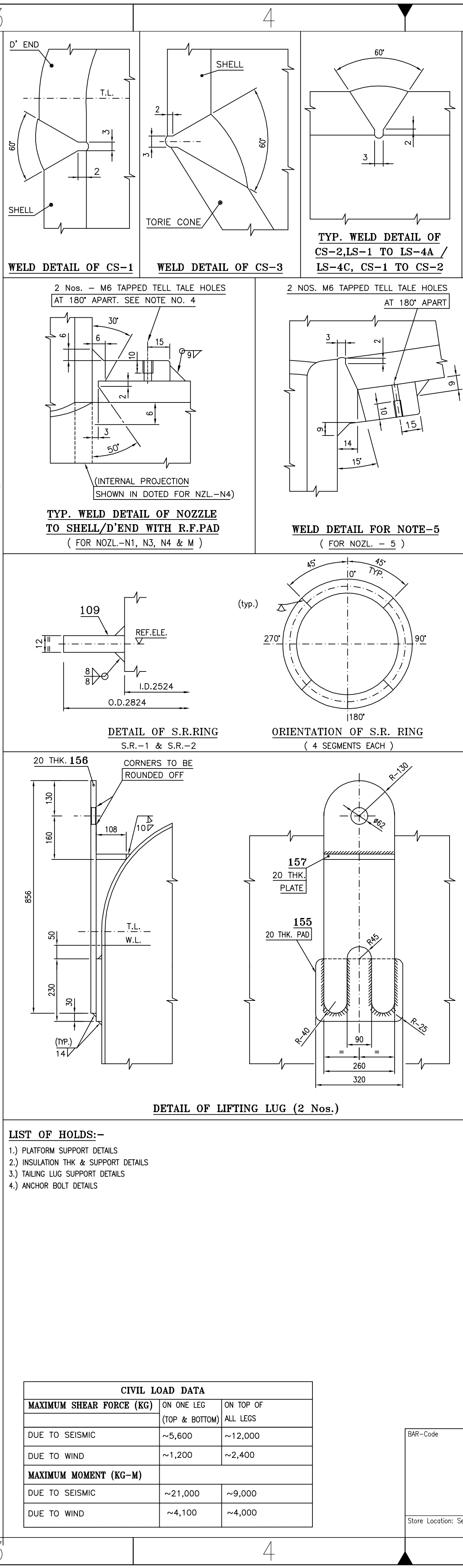
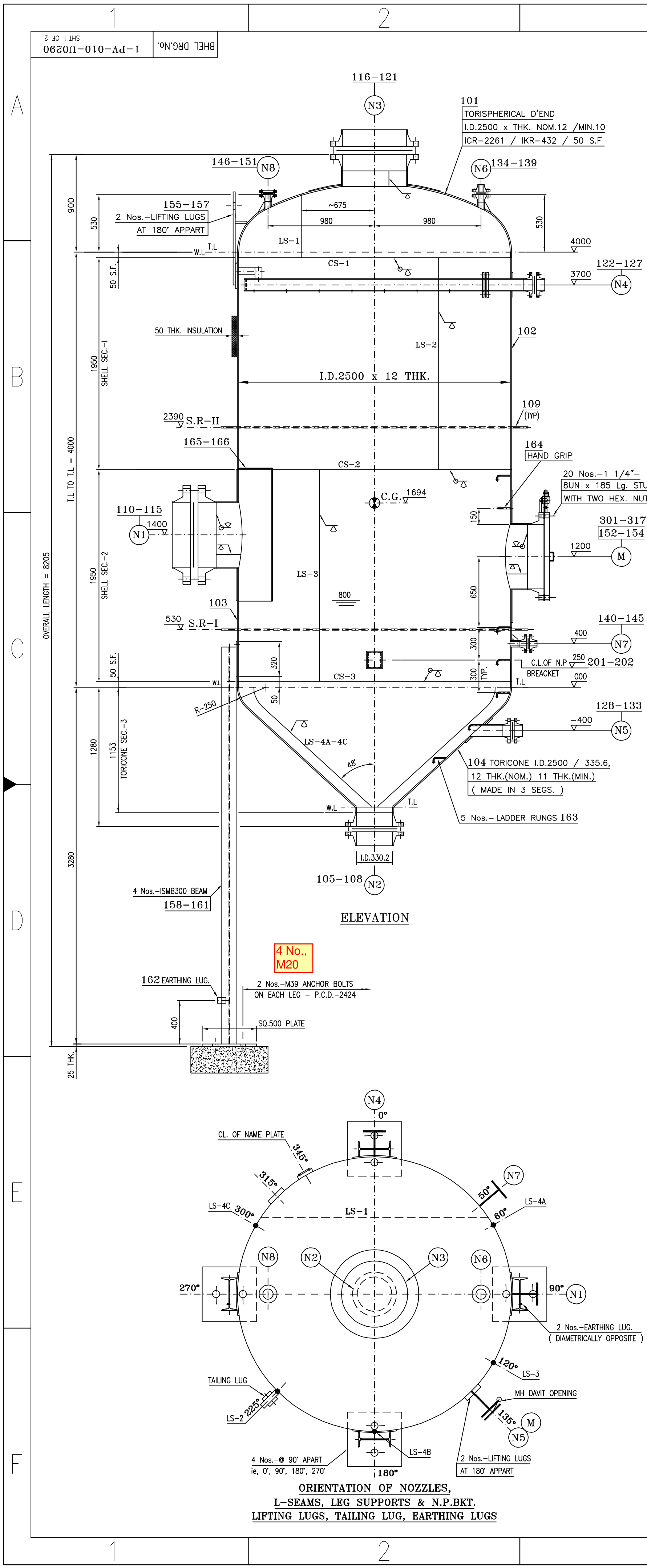
thysenkruupp

BHHEL Drawing NO.1-48-800-U0148 REV. 0

FAB. DETAILS OF ACCESS DOOR, PEEP HOLE AND TUBE PULLING DOOR AND SPIGOT

REV	DATE	DESCRIPTION	PPD	CHD	APPD
1	26-04-2023	K K RAO			
2	26-04-2023	S KUMAR MANIKYAM			
3	26-04-2023	PK SAHOO			





DESIGN DATA									
FLUID HANDLED					STEAM + AIR + COKE PARTICLES				
OPERATING PRESSURE (Kg/Cm ² g)					1.033				
DESIGN PRESSURE (Kg/Cm ² g)					3.5 & FULL VACUUM				
OPERATING TEMPERATURE (°C)					260				
DESIGN TEMPERATURE (°C)					350 INT / 100 EXT. (NOTE-15)				
MDMT (°C)					MINIUS 0.7°C				
CORROSION ALLOWANCE (mm)					3.0 (INTERNAL)				
TYPE OF HEAD					2:1 ELLIPTICAL				
JOINT EFFICIENCY					SHELL: 1.0 HEAD: 1.0				
RADIOGRAPHY					SHELL / HEAD : FULL				
POST WELD HEAT TREATMENT					NOT REQUIRED				
HEAT TREATMENT					FABRICATE/EMPTY WEIGHT (Kg) ~7,000				
SP.GRAVITY OF OPER. MEDIUM					1.6 MAXIMUM				
CAPACITY (M ³)					25				
INSULATION THICKNESS (MM) (AT SITE)					50 (HOT)				
FIRE PROOFING (BY OTHERS)					-NIL-				
HYDROSTATIC TEST (kg/cm ² g)					13.99 (HORIZONTAL)				
PRESSURE (NEW & COLD)					ASME SEC VIII DIV.1				
DESIGNED TO					EDITION 2021				
INSPECTION : TPI					MATERIAL OF CONSTRUCTION				
SL.NO.					DESCRIPTION				
01.					SHELL , D'END , TORICONE				
02.					NOZZLE FLANGES / FORGINGS				
03.					PIPE (INT. / EXT.)				
04.					GASKET				
05.					FASTNERS (EXTERNAL)				
06.					FASTNERS (INTERNAL)				
07.					SUPPORTS				
1 26					COMP. FLANGE-(N4)				
1 25					GASKET-(N4)				
1 24					W.N.FLANGE-(N4)				
1 23					NOZZLE PIPE-(N4)				
1 22					R.F.PAD (N4) 230 x 230				
1 21					STUD WITH 2 HEX.NUTS-(N3)				
1 20					COMP. FLANGE-(N3)				
1 19					GASKET-(N3)				
1 18					W.N.FLANGE-(N3)				
1 17					FAB. NOZZLE-(N3)				
1 16					R.F.PAD (N3) 1215 x 1220				
1 15					STUD WITH 2 HEX.NUTS (N1)				
1 14					COMP. FLANGE-(N1)				
1 13					GASKET-(N1)				
1 12					W.N.FLANGE-(N1)				
1 11					NOZZLE PIPE-(N1)				
1 10					R.F.PAD (N1) 12355 x 350				
1 09					STIFFENER RING, (S.R.-1 & 2)(12 x 1175 x 2000)				
1 08					STUD WITH 2 HEX.NUTS (N2)				
1 07					COMP. FLANGE (N2)				
1 06					GASKET FOR (N2)				
1 05					W.N.FLANGE-(N2)				
1 04					TORICONE SECTION-4				
1 03					SHELL SECTION-II				
1 02					SHELL SEC.-I				
1 01					TOP DISHED END (BLANK DIA3050(2200+850))				

- LIST OF HOLDS:-
- 1) PLATFORM SUPPORT DETAILS
 - 2) INSULATION THK & SUPPORT DETAILS
 - 3) TAILING LUG SUPPORT DETAILS
 - 4) ANCHOR BOLT DETAILS

CIVIL LOAD DATA			
MAXIMUM SHEAR FORCE (KG)		ON ONE LEG (TOP & BOTTOM)	ON TOP OF ALL LEGS
DUE TO SEISMIC		~5,600	~12,000
DUE TO WIND		~1,200	~2,400
MAXIMUM MOMENT (KG-M)			
DUE TO SEISMIC		~21,000	~9,000
DUE TO WIND		~4,100	~4,000

TABLE OF NOZZLES AND FLANGES									
MARK NO.	QTY.	SERVICE	NPS/NB (SIZE)	O.D.	SCH	CLASS	TYPE/ FACE	PAD SIZE WIDTH x THK. FROM COL. C.L.	PROJ. OF NOZ. FROM COL. C.L.
M	1	MANHOLE (WITH DAVIT)	24" (600)	610.0	12 THK.	150#	W.N./R.F.	300 x 12	1560
N8	1	SPARE (WITH B.F)	2" (50)	60.3	150#	W.N./R.F.	-	AS PER DRG.	
N7	1	TEMP.GAUGE WITH COMP. FLG.	2" (50)	60.3	300#	W.N./R.F.	-	1400	
N6	1	PRESSURE GAUGE WITH COMP. FLG.	2" (50)	60.3	300#	W.N./R.F.	-	AS PER DRG.	
N5	1	SEAL WITH COMP. FLG.	4" (100)	114.3	150#	W.N./R.F.	55 x 12	1250	
N4	1	WATER INLET WITH COMP. FLG.	4" (100)	114.3	150#	W.N./R.F.	55 x 12	1450	
N3	1	VAPOUR OR STEAM OUTLET WITH COMP. FLG.	24" (600)	610.0	12 THK.	150#	W.N./R.F.	300 x 12	900
N2	1	COKE OUTLET WITH COMP. FLG.	14" (350)	355.6	12.7 XS	150#	W.N./R.F.	-	AS PER DRG.
N1	1	VAPOUR INLET WITH COMP.FLG	6(150) 168.3	10.97 80	300#	W.N./R.F.	85 x 12	1625	

tkS India / Owner/Client

Category Codes (Submission purpose)

1 For Approval

2 For Review / Comments

3 For Information

4 For Engineering

5 For Enquiry

6 For Order Placement

7 Final & Approved

8 Released for Construction

tkS India / Owner/Client

Acceptance Codes (Approval Codes)

1 Approved

2 Approved for Manufacturing/ Fabrication With Comments as Marked

3 Not Approved/Resubmit

4 Retained for Information/Records

5 Reviewed

6 Reviewed as Noted/Resubmit

BHEL Drawing NO.: 1-PV-010-U0290

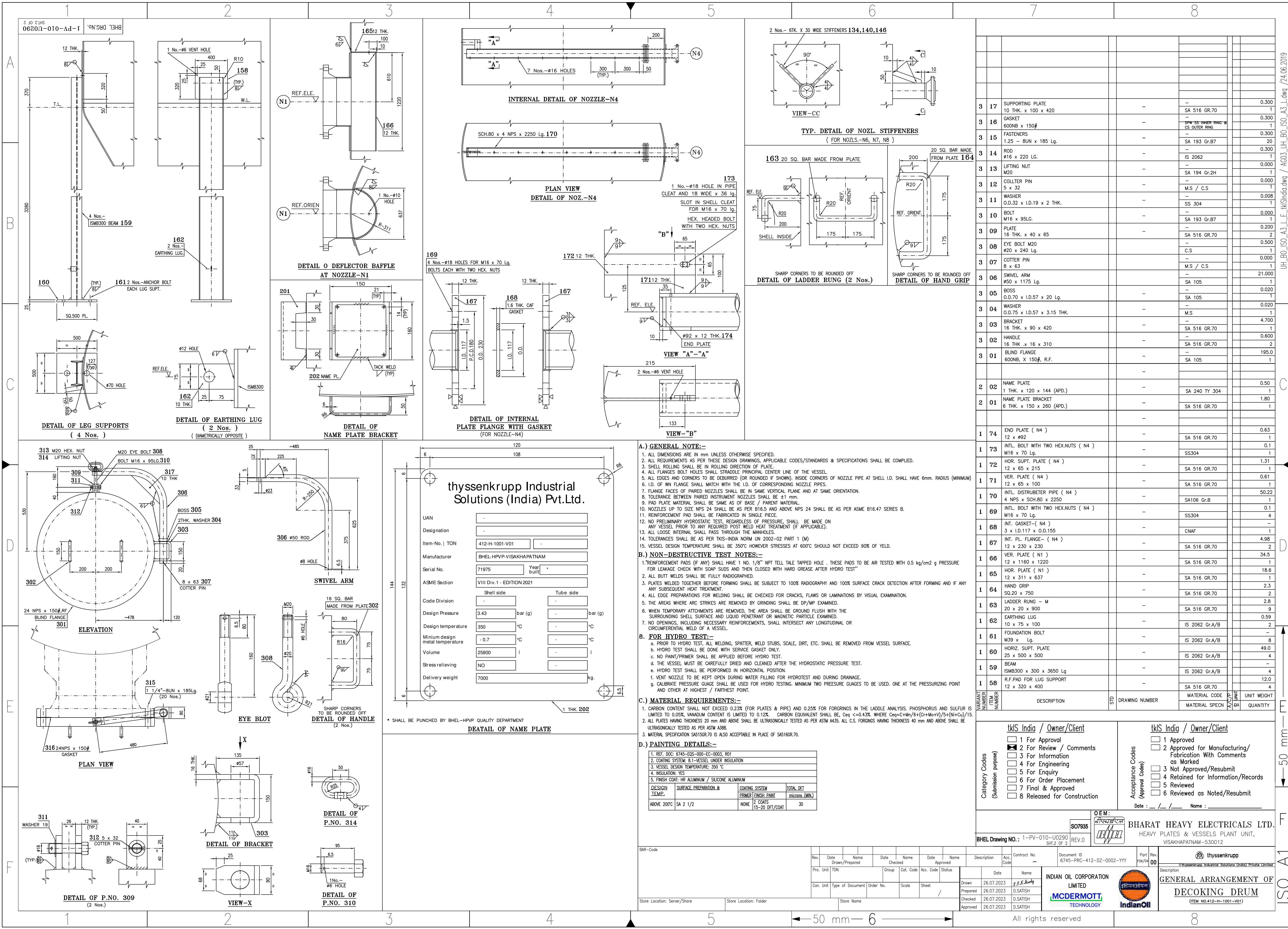
INDIAN OIL CORPORATION LIMITED

CDERMOTT TECHNOLOGY

IndianOil

GENERAL ARRANGEMENT OF DECOCKING DRUM

(ITEM NO.412-H-1001-V01)



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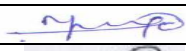
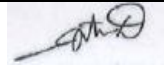
DOCUMENT CATEGORY (USE "X" MARK)		DOCUMENT REVIEW STATUS (BY CLIENT)				
☐ APPROVAL ☒ REVIEW ☐ INFORMATION						
00	28.07.23	First Submission	SSNM	Satish D	Satish D	
REV	DATE	DETAILS OF REVISION	PREPARED	CHECKED	APPROVED	
CLIENT	 INDIAN OIL CORPORATION LIMITED PANIPAT REFINERY					
CONSULTANT	 THYSSENKRUPP INDUSTRIAL SOLUTIONS, INDIA PVT. LTD. (tkIS-India)					
PROJECT	FIRED HEATER FOR INDMAX UNIT OF PANIPAT REFINERY EXPANSION (P-25) PROJECT					
ESC	 AG FURNACE IMPROVEMENTS PVT. LTD. NOIDA, INDIA					
 BHEL VISAKHAPATNAM		NAME	SIGN	DATE		
		DRN	SSNM		28.07.23	
		CHD	SATISH.D		28.07.23	
		APPD	SATISH.D	28.07.23		
The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company		TITLE: DESIGN CALCULATIONS OF DECOKING DRUM				
		BHEL/AGFIS DRG/DOC No.PPPV-7935-PV-010-001				REV
		CUST. DRG/ DOC NO. 6745-PRC-412-DZ-0002-XXXX				00
		SHT NO. 01		NO. OF SHT. 125		

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Rev.0
DECOKING DRUM

Reference # : 6745-PRC-412-DZ-0002-143
Revision # : 0
Client Name : tkIS
Drawing # : 6745-PRC-412-DZ-0002-143

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2021

Analysis Performed by : #BHEL-HPVP-Vizag

Job File : ...\\Decoking Drum_R0-28072023.pvdb

Date of Analysis : Jul 28, 2023 3:11pm

PV Elite 24, January 2022

(ITEM NO.412-H-1001-V01)

Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Vessel Design Summary: Step: 33 3:11pm Jul 28,2023

Vessel Design Summary:

ASME Code, Section VIII Division 1, 2021

Diameter Spec : 2500.000 mm ID
 Vessel Design Length, Tangent to Tangent 533.63 cm
 Distance of Bottom Tangent above Grade 30.00 cm
 Specified Datum Line Distance 0.00 cm
 Internal Design Temperature 350 °C
 Internal Design Pressure 3.500 kgf/cm²
 External Design Temperature 150 °C
 External Design Pressure 1.055 kgf/cm²
 Maximum Allowable Working Pressure 5 kgf/cm²
 External Max. Allowable Working Pressure 1 kgf/cm²
 Shop Test Pressure 13.998 kgf/cm²
 Required Minimum Design Metal Temperature -0.7 °C
 Warmest Computed Minimum Design Metal Temperature -48.0 °C
 Wind Design Code IS 875 (PART 3) Amd. 1&2 (2020)
 Earthquake Design Code IS 1893 RSM Amd. 1&2 (2018)

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normal ized	Impact Tested
Shell	SA-516 70	...	...	K02700	Yes	No
Head	SA-516 70	...	...	K02700	Yes	No
Cone	SA-516 70	...	...	K02700	Yes	No
Flange	SA-105	...	...	K03504	Yes	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle	SA-516 70	...	...	K02700	Yes	No
Re-Pad	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-105	...	...	K03504	Yes	No
Rings	SA-516 70	...	...	K02700	Yes	No
Leg Baseplate	SA/IS 2062	...	...	...	No	No
Flg Bolting	SA-193 B7	...	<= 2 1/2	G41400	No	No
Leg Bolting	SA/IS 2062	...	...	...	No	No

Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.

Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (kgf/ cm² & mm):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Total Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Body Flng-N2	3.844	1.05	8.000	3.0000	N/A	No
ToriCone	3.844	1.05	7.000	3.0000	N/A	No
Shell-Sec-2	3.660	1.05	9.000	3.0000	N/A	No
Shell-Sec-1	3.500	1.05	9.000	3.0000	N/A	No
Top DEnd	3.500	1.05	7.000	3.0000	No	No

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Vessel Design Summary: Step: 33 3:11pm Jul 28,2023

Liquid Level: 215.30 cm Dens.: 1599.270 kg/m³ Sp. Gr.: 1.600**Stiffener Ring Specifications:**

Elevation cm	Selected Type	Ring Description
180.63	Bar***** x 12.00	SR 1 Fr 20
428.63	Bar***** x 12.00	SR 2 Fr 30

Element Types and Properties:

Element Type	"To" Elev cm	Element Length cm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Body Flg	13.3	12.7	12.0	35.1	...	...	1.00	1.00
Conical	128.6	115.3	12.0	11.0	7.0	...	1.00	1.00
Cylinder	328.6	200.0	12.0	12.0	6.5	...	1.00	1.00
Cylinder	528.6	200.0	12.0	12.0	6.4	...	1.00	1.00
Ellipse	533.6	5.0	12.0	10.0	6.3	...	1.00	1.00

External Pressure Calculations:

From	To	External Actual T. mm	External Required T. mm	External Design Pressure kgf/cm ²	External M.A.W.P. kgf/cm ²
10	20	35.052	No Calc	1.05461	No Calc
20	30	11	9.69043	1.05461	1.63271
30	Ring	12	9.80819	1.05461	2.11054
Ring	40	12	11.038	1.05461	1.39869
40	Ring	12	11.038	1.05461	1.39869
Ring	50	12	9.07139	1.05461	2.85254
50	60	10	9.52698	1.05461	1.21308

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners cm	Allowable Length Bet. Stiffeners cm	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	167.3	254.166	No Calc	No Calc
30	Ring	167.3	325.324	No Calc	No Calc
Ring	40	248	325.368	237.097	854.132
40	Ring	248	325.368	No Calc	No Calc
Ring	50	125.833	325.419	213.327	854.132
50	60	No Calc	No Calc	No Calc	No Calc

Loads for Foundation/ Support Design:

Total Wind Shear on top of all Legs	2245.	kgf
Total Earthquake Shear on top of all Legs	11996.	kgf
Total Wind Moment at top of all Legs	3756.	kgf-m.
Total Earthquake Moment at top of all Legs	10436.	kgf-m.
Max. Wind Shear on one Leg (top & bottom)	1066.	kgf
Max. Earthq. Shear on one Leg (top & bottom)	5698.	kgf
Max. Wind Moment at base of one Leg	3891.	kgf-m.

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Vessel Design Summary: Step: 33 3:11pm Jul 28,2023

Max. Earthquake Moment at base of one Leg	20796. kgf-m.
Max. Vertical Load (Wt. + Wind) on one Leg	22918. kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	22918. kgf

Note: The Wind and Seismic loads were not load factored in this analysis.

Note:

Wind and Earthquake moments include the effects of user defined forces and moments if any exist in the job and were specified to act (compute loads and stresses) during these cases. Also included are moment effects due to eccentric weights if any are present in the input.

Local Stress Analysis Results:

Description	Analysis Type	Max Stress Ratio	High Stress Location	Pass Fail
Lift Lug	WRC-107/537	0.706	n/a	Passed
LEGS	WRC-107/537	0.797	n/a	Passed

Weights:

Fabricated - Bare W/O Removable Internals	6499.9 kg
Shop Test - Fabricated + Water (Full)	31117.3 kg
Shipping - Fab. + Rem. Intls.+ Shipping App.	6499.9 kg
Erected - Fab. + Rem. Intls.+ Insul. (etc)	12216.6 kg
Empty - Fab. + Intls. + Details + Wghts.	12216.6 kg
Operating - Empty + Operating Liquid (No CA)	24372.1 kg
Field Test - Empty Weight + Water (Full)	36834.0 kg

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Summary: Step: 31 3:11pm Jul 28,2023

Nozzle Calculation Summary (kgf/cm² & mm):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
N5-100-SEAL	5	OK	...	OK	6.49	OK	Passed
M-600-MH	9	OK	...	...		OK	Passed
N7-50-Temp Gaug	9	...	...	OK	6.42	OK	No Calc[*]
N1-600-Vapour O	9	OK	...	OK	6.35	OK	Passed
N4-100-Water Ou	5	OK	...	OK	6.35	OK	Passed
N3-600-Steam Ou	7	OK	...	OK	6.34	OK	Passed
N6-50-PG	7	...	...	OK	6.34	OK	No Calc[*]
N8-50-SPARE	7	...	...	OK	6.34	OK	No Calc[*]

Nozzle MAWP Summary:

Minimum MAWP Nozzles :	5 Nozzle : N4-100-Water Ou
Minimum MAWP Shells/Flanges :	5 Element : ToriCone
Minimum MAPnc Shells/Flanges :	11 Element : ToriCone
Computed Vessel M.A.W.P. :	5 kgf/cm ²

[*] - This was a small opening and the areas were not computed or the MAWP of this connection could not be computed because the longitudinal bending stress was greater than the hoop stress.

Note: MAWPs (Internal Case) shown above are at the High Point.

Multiple output lines for the same nozzle indicates required Code calculations in both the longitudinal and circumferential planes of reinforcement where applicable.

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	Y Coordinate mm	Layout Angle deg	Dia. Limit mm
20	N5-100-SEAL	886.350	315.000	238.285
30	M-600-MH	2486.350	0.000	1183.200
30	N7-50-Temp Gauge	1686.350	0.000	97.700
30	N1-600-Vapour Ou	2686.350	90.000	1183.200
40	N4-100-Water Out	4986.360	0.000	206.361
50	N3-600-Steam Out	0.000	0.000	1183.200
50	N6-50-PG	0.000	0.000	97.700
50	N8-50-SPARE	0.000	180.000	97.700

The nozzle spacing is computed by the following:

$$= \sqrt{l_l^2 + l_c^2} \text{ where}$$

l_l - Arc length along the inside vessel surface in the long. direction.

l_c - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.

No interference violations have been detected!

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Schedule: Step: 30 3:11pm Jul 28,2023

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm	Reinforcing Pad Diameter	Pad Thk mm	Cut Length mm	Flg Class
N7-50-Temp Gauge	2.000 in	160	WNF	2.375	8.738	...	...	162.3	300
N6-50-PG	2.000 in	160	WNF	2.375	8.738	...	...	175.9	300
N8-50-SPARE	2.000 in	160	WNF	2.375	8.738	...	...	175.9	150
N5-100-SEAL	4.000 in	80	WNF	4.500	8.560	278.28	12.00	162.5	150
N4-100-Water Out	4.000 in	80	WNF	4.500	8.560	224.30	12.00	163.3	150
M-600-MH	24.000 in	Actual	WNF	24.000	12.000	1209.60	12.00	199.7	150
N1-600-Vapour Ou	24.000 in	Actual	WNF	24.000	12.000	1209.60	12.00	199.7	300
N3-600-Steam Out	24.000 in	Actual	WNF	24.000	12.000	1209.60	12.00	180.6	150

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows:

Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
N7-50-Temp	SA-106 B	10.000	10.000	...	...	...
N6-50-PG	SA-106 B	10.000	10.000	...	...	...
N8-50-SPARE	SA-106 B	10.000	10.000	...	...	...
N5-100-SEAL	SA-106 B	11.000	10.000	10.000	12.000	...
N4-100-Wate	SA-106 B	12.000	10.000	10.000	12.000	...
M-600-MH	SA-516 70	10.000	10.000	8.000	12.000	...
N1-600-Vapo	SA-516 70	10.000	10.000	8.000	12.000	...
N3-600-Stea	SA-516 70	10.000	10.000	8.000	12.000	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum cm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
N7-50-Temp Gauge	168.635	0.0	150.00	0.00	Shell-Sec-2
N6-50-PG	...	0.0	150.00	0.00	Top DEnd
N8-50-SPARE	...	180.0	150.00	0.00	Top DEnd
N5-100-SEAL	88.635	315.0	150.00	0.00	ToriCone
N4-100-Water Out	498.636	0.0	150.00	0.00	Shell-Sec-1
M-600-MH	248.635	0.0	150.00	0.00	Shell-Sec-2
N1-600-Vapour Ou	268.635	90.0	150.00	0.00	Shell-Sec-2
N3-600-Steam Out	...	0.0	150.00	0.00	Top DEnd

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Bill of Material: Step: 29 3:11pm Jul 28,2023

Bill of Materials:

QTY	DESCRIPTION	MATERIAL
1	BODY FLANGE: 35.1mm THK X 533.4mm OD	SA-105
1	CONE: 12.0mm THK X 2433.0mm ID X 115.3mm	SA-516 70
2	CYLINDER: 12.0mm THK X 2500.0mm ID X 200.0mm	SA-516 70
1	ELLIPTICAL HEAD: 2.0 X 1, 12.0mm THK X 2500.0mm ID X 5.0mm	SA-516 70
1	INSULATION: 127mm X 50mm THK	Insulation
1	INSULATION: 1153mm X 50mm THK	Insulation
2	PLATFORM: 1000mm X 1200mm WIDE	
2	INSULATION: 2000mm X 50mm THK	Insulation
2	BAR RING STIFFENER: 2524.0mm ID X 2824.0mm OD X 12.0mm	SA-516 70
4	LEGS, SHAPE: ISMB300 365.0mm	...
4	BASEPLATES: 500.0mm X 500.0mm X 25.0mm	SA/IS 2062
8	BASEPLATE BOLTS: 39.0mm	SA/IS 2062
4	LEG RE-PADS: 400.000mm X 320.000mm X 12.000mm	SA-516 70
1	LADDER: 5000.0mm	...
2	LIFTING LUGS:	SA-516 70
2	LIFTING LUG PADS: 320.0mm X 230.0mm X 20.0mm THK	
1	INSULATION: 675mm X 50mm THK	Insulation
1	CLASS 150 GR 1.1, 24.0" BLIND FLANGE (S)	SA-105
1	NAMEPLATE	...

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

MDMT Summary: Step: 32 3:11pm Jul 28,2023

Minimum Design Metal Temperature Results Summary (°C):

Description	Notes	Curve	Basic MDMT	Reduced MDMT	UG-20 (f) MDMT	Thickness ratio	Gov Thk mm	E*	PWHT reqd
Body Flng-N2	[5]	B	-18	-104		0.192		1.00	No
ToriCone	[8]	D	-48	-48		0.611	11.000	1.00	No
Shell-Sec-2	[8]	D	-48	-48		0.481	12.000	1.00	No
Shell-Sec-1	[8]	D	-48	-48		0.465	12.000	1.00	No
Top DEnd	[10]	D	-48	-48		0.595	10.000	1.00	No
Top DEnd	[7]	D	-48	-48		0.465	12.000	1.00	No
SR 1 Fr 20	[23]	D	-48	-48		0.481	12.000	1.00	No
SR 2 Fr 30	[23]	D	-48	-48		0.465	12.000	1.00	No
N5-100-SEAL	[1]	B	-26	-48		0.406	11.000	1.00	No
Nozzle Flg	[5]	B	-18	-104					
M-600-MH	[1]	D	-23	-104		0.084	12.000	1.00	No
Nozzle Flg	[5]	B	-18	-104					
N7-50-Temp Gau	[1]	C	-29	-104		0.019	7.645	1.00	No
Nozzle Flg	[5]	B	-18	-104					
N1-600-Vapour	[1]	D	-23	-104		0.084	12.000	1.00	No
Nozzle Flg	[5]	B	-18	-104					
N4-100-Water O	[1]	B	-29	-104		0.037	7.490	1.00	No
Nozzle Flg	[5]	B	-18	-104					
N3-600-Steam O	[1]	D	-48	-48		0.400	10.000	1.00	No
Nozzle Flg	[5]	B	-18	-104					
N6-50-PG	[1]	C	-29	-104		0.019	7.645	1.00	No
Nozzle Flg	[5]	B	-18	-104					
N8-50-SPARE	[1]	C	-29	-104		0.019	7.645	1.00	No
Nozzle Flg	[5]	B	-18	-104					
Nozl. Bolting	[22]		-48			1.000	63.500	1.00	No
Bolting	[21]		-48						
Warmest MDMT:			-18	-48					
Required Minimum Design Metal Temperature						-0.7	°C		
Warmest Computed Minimum Design Metal Temperature						-48.0	°C		

Notes:

- [!] - This was an impact tested material.
- [1] - Governing Nozzle Weld.
- [4] - ASME Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-c).
- [5] - ASME Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-b).
- [6] - MDMT Calculations at the Shell/Head Joint.
- [7] - MDMT Calculations for the Straight Flange.
- [8] - Cylinder/Cone/Flange Junction MDMT.
- [9] - Calculations in the Spherical Portion of the Head.
- [10] - Calculations in the Knuckle Portion of the Head.
- [11] - Calculated (Body Flange) Flange MDMT.
- [12] - Calculated Flat Head MDMT per UCS-66.3
- [13] - Tubesheet MDMT, shell side, if applicable
- [14] - Tubesheet MDMT, tube side, if applicable
- [15] - Nozzle Material
- [16] - Shell or Head Material
- [17] - Impact Testing required
- [18] - Impact Testing not required, see UCS-66(b)(3)
- [20] - Cylinder/Cone Junction MDMT based on Longitudinal Stress considerations
- [21] - Body Flange Bolting Material
- [22] - Nozzle Flange Bolting Material
- [23] - Stiffening Ring to Shell Weld

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FileName : Decoking Drum_R0-28072023 -----

MDMT Summary: Step: 32 3:11pm Jul 28,2023

[24] - Saddle to Shell Weld

UG-84(b)(2) was not considered.

UCS-66(g) was not considered.

UCS-66(i) was not considered.

Notes:

Impact test temps were not entered in and not considered in the analysis.

UCS-66(i) applies to impact tested materials not by specification and

UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c).

The Basic MDMT includes the (30F) PWHT credit if applicable.

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Warnings and Errors: Step: 0 3:11pm Jul 28,2023

Class From To : Basic Element Checks.

Class From To: Check of Additional Element Data

There were no geometry errors or warnings.

*PV Elite performs all calculations internally in Imperial Units
to remain compliant with the ASME Code and any built in assumptions
in the ASME Code formulas. The finalized results are reflected to show
the set of selected units for this analysis.*

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

Units used in this Analysis (Kgf_cm2):

Name	System Unit	Constant	User Unit
Length	Feet	30.4800	cm
Force	Pounds	0.4536	kgf
Mass	Pounds	0.4536	kg
Area	sq. inches	6.4516	cm ²
Moment	ft. lbs.	0.1383	kgf-m.
Stress	lbs./sq.in.	0.0703	kgf/cm ²
Temperature	Degrees F	0.5556	°C
Pressure	psig	0.0703	kgf/cm ²
Elast. Modulus	lbs./sq.in.	0.0703	kgf/cm ²
Pipe Density	lbs./cu.in.	0.0277	kg/cm ³
Ins. Density	lbs./cu.ft.	0.1600E-04	kg/cm ³
Fluid Density	lbs./cu.ft.	16.0183	kg/m ³
Wind Speed	miles/hr	1.6093	km/hr
Tray Weight	lbs./sq.ft.	0.0005	kgf/cm ²
Inertia	in.**4	41.6231	cm**4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	4.8824	kgf/m ²
Elevation	Feet	0.3048	m
Volume	in.**3	16.3871	cm ³
Diameter	inches	25.4000	mm
Thickness	inches	25.4000	mm

PV Elite Vessel Analysis Program: Input Data

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Design Internal Pressure (for Hydrotest)	3.5	kgf/cm ²
Design Internal Temperature	350.0	°C
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-0.7	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-1	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	

User Spectrum Data points specified for increments of Time Period

Time Period	Sa/g
0.010	0.160
0.050	0.392
0.100	0.560
0.130	0.560
0.200	0.560
0.270	0.560
0.300	0.560
0.400	0.560
0.500	0.560

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

0.550	0.560
0.600	0.516
0.670	0.460
0.800	0.385
1.000	0.308
1.200	0.257
1.400	0.220
1.600	0.193
1.800	0.171
2.000	0.154
2.400	0.128
2.800	0.110
3.000	0.103
3.500	0.088
4.000	0.077
4.500	0.068
5.000	0.062
5.500	0.056
6.000	0.051
6.500	0.047
7.000	0.044

Consider Vortex Shedding

N

Shop Pressure Test:

Type of Pressure Test	UG-99 (c)
Pressure Test Position	Horizontal

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW
Load Case 20	BL+IP+OW

Wind Design Code	IS 875 (PART 3):2015-2020	
Basic Wind Speed for IS-875	169.2	km/hr
Wind Zone Number	1	
Base Elevation	30	cm
Percent Wind for Hydrotest	33.0	
Risk Factor	[k1] 1.0	
Terrain Category	2	
Equipment Class	Class A	
Topography Factor	[k3] 1.0	
Importance Factor	[k4] 1.0	
Damping Factor (Beta) for Wind (Ope)	0.0100	
Damping Factor (Beta) for Wind (Empty)	0.0000	
Damping Factor (Beta) for Wind (Filled)	0.0000	

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

Seismic Design Code	IS 1893-RSM
Importance Factor for IS-1893	1.500
Soil Factor	1.000
Zone Number	4.000
Percent Seismic for Hydrotest	0.000
Period of Vibration (User defined) Sec	0.000
Damping Factor	2.000

User Spectrum Data points specified for increments of Time Period

Time Period	Sa/g
0.010	0.160
0.050	0.392
0.100	0.560
0.130	0.560
0.200	0.560
0.270	0.560
0.300	0.560
0.400	0.560
0.500	0.560
0.550	0.560
0.600	0.516
0.670	0.460
0.800	0.385
1.000	0.308
1.200	0.257
1.400	0.220
1.600	0.193
1.800	0.171
2.000	0.154
2.400	0.128
2.800	0.110
3.000	0.103
3.500	0.088
4.000	0.077
4.500	0.068
5.000	0.062
5.500	0.056
6.000	0.051
6.500	0.047
7.000	0.044

Consider Vertical Acceleration	Yes
Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N
Perform Blast Load Analysis	No
Material Database Year	Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	Yes

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FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

For thickness ratios <= 0.35, MDMT will be -155F (-104C) Yes
 For PWHT & P1 Materials the MDMT can be < -55F (-48C) No

Using Metric Material Databases, ASME II D No
 Calculate B31.3 type stress for Nozzles with Loads Yes
 Reduce the MDMT due to lower membrane stress Yes
 Consider Longitudinal Stress in MDMT Calculations Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Flange	
Description	Body Flng-N2	
Distance "FROM" to "TO"	12.7	cm
Flange Inside Diameter	330.2	mm
Element Thickness	35.052	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	12	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	3.5	kgf/cm ²
Design Temperature Internal Pressure	350	°C
Design External Pressure	1.0546	kgf/cm ²
Design Temperature External Pressure	150	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-105	[Normalized]
Allowable Stress, Ambient	1406.1	kgf/cm ²
Allowable Stress, Operating	1241.4	kgf/cm ²
Allowable Stress, Hydrotest	1828	kgf/cm ²
Material Density	0.00775	kg/cm ³
P Number Thickness	29.007	mm
Yield Stress, Operating	1862.1	kgf/cm ²
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03504	
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	Y	
Weld is pre-Heated	No	

Element From Node	10	
Detail Type	Insulation	
Detail ID	Ins: 10	
Dist. from "FROM" Node / Offset dist	0	cm
Height/Length of Insulation	12.7	cm
Thickness of Insulation	50	mm
Density	0.0002	kg/cm ³

Element From Node	20	
Element To Node	30	
Element Type	Conical	
Description	ToriCone	
Distance "FROM" to "TO"	115.3	cm
Inside Diameter	355.6	mm
Element Thickness	11	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	12	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	3.5	kgf/cm ²
Design Temperature Internal Pressure	350	°C

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FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

Design External Pressure	1.0546	kgf/cm ²
Design Temperature External Pressure	150	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	[Normalized]
Allowable Stress, Ambient	1406.1	kgf/cm ²
Allowable Stress, Operating	1310	kgf/cm ²
Allowable Stress, Hydrotest	1828	kgf/cm ²
Material Density	0.00775	kg/cm ³
P Number Thickness	30.988	mm
Yield Stress, Operating	1965.9	kgf/cm ²
UCS-66 Chart Curve Designation	D	
External Pressure Chart Name	CS-2	
UNS Number	K02700	
Product Form	Plate	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Cone Diameter at "To" End	2500	mm
Design Length of Cone	1153	mm
Large knuckle radius	250	mm
Large knuckle thickness	12	mm
Small knuckle radius	35.6	mm
Small knuckle thickness	12	mm
Half Apex Angle of Cone	30.0	degrees
Toriconical (Y/N)	Y	
Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Liquid	
Detail ID	Liquid: 20	
Dist. from "FROM" Node / Offset dist	0	cm
Height/Length of Liquid	115.3	cm
Liquid Density	1599.3	kg/m ³
Element From Node	20	
Detail Type	Insulation	
Detail ID	Ins: 20	
Dist. from "FROM" Node / Offset dist	0	cm
Height/Length of Insulation	115.3	cm
Thickness of Insulation	50	mm
Density	0.0002	kg/cm ³
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N5-100-SEAL	
Dist. from "FROM" Node / Offset dist	75.3	cm
Nozzle Diameter	4	in.
Nozzle Schedule	80	
Nozzle Class	150	
Layout Angle	315.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	16.563	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	30	
Element To Node	40	
Element Type	Cylinder	! Atype
Description	Shell-Sec-2	
Distance "FROM" to "TO"	200	cm

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FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

Inside Diameter	2500	mm
Element Thickness	12	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	12	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	3.5	kgf/cm ²
Design Temperature Internal Pressure	350	°C
Design External Pressure	1.0546	kgf/cm ²
Design Temperature External Pressure	150	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	[Normalized]
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

Element From Node	30	
Detail Type	Platform	
Detail ID	PLAT:[1 OF 2]	
Dist. from "FROM" Node / Offset dist	50	cm
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	360.0	
Platform Wind Area	28800	cm ²
Platform Weight	2516.1	kgf
Platform Railing Weight	0	kgf/cm
Platform Grating Weight	0.017	kgf/cm ²
Platform Width	1200	mm
Platform Height	1000	mm
Platform Clearance or End Offset	100	mm
Platform Force Coefficient	1.2	
Ladder Layout Angle	0.0	
Ladder Start Elevation	0	cm
Ladder End Elevation	0	cm
Unit Weight of Ladder	0	kgf/cm
Platform Length (top head platform)	0	mm

Element From Node	30	
Detail Type	Liquid	
Detail ID	Liquid: 30	
Dist. from "FROM" Node / Offset dist	0	cm
Height/Length of Liquid	100	cm
Liquid Density	1599.3	kg/m ³

Element From Node	30	
Detail Type	Insulation	
Detail ID	Ins: 30	
Dist. from "FROM" Node / Offset dist	0	cm
Height/Length of Insulation	200	cm
Thickness of Insulation	50	mm
Density	0.0002	kg/cm ³

Element From Node	30	
Detail Type	Ring	
Detail ID	SR 1 Fr 20	
Dist. from "FROM" Node / Offset dist	52	cm
Inside Diameter of Ring	2524	mm
Thickness of Ring	12	mm
Outside Diameter of Ring	2824	mm
Material Name	SA-516 70	[Normalized]
Height of Section Ring	0	mm
Using Custom Stiffener Section	No	

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FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

Element From Node	30	
Detail Type	Nozzle	
Detail ID	M-600-MH	
Dist. from "FROM" Node / Offset dist	120	cm
Nozzle Diameter	24	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	428.05	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-516 70	[Normalized]

Element From Node	30	
Detail Type	Nozzle	
Detail ID	N7-50-Temp Gauge	
Dist. from "FROM" Node / Offset dist	40	cm
Nozzle Diameter	2	in.
Nozzle Schedule	160	
Nozzle Class	300	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	4.5539	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	30	
Detail Type	Nozzle	
Detail ID	N1-600-Vapour Ou	
Dist. from "FROM" Node / Offset dist	140	cm
Nozzle Diameter	24	in.
Nozzle Schedule	None	
Nozzle Class	300	
Layout Angle	90.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	365.82	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-516 70	[Normalized]

Element From Node	30	
Detail Type	Leg	
Detail ID	LEGS	
Dist. from "FROM" Node / Offset dist	32	cm
Diameter at Leg Centerline	2640.1	mm
Leg Orientation	2	
Number of Legs	4	
Section Identifier	ISMB300	
Length of Legs	365	cm

Element From Node	40	
Element To Node	50	
Element Type	Cylinder	! Atype
Description	Shell-Sec-1	
Distance "FROM" to "TO"	200	cm
Inside Diameter	2500	mm
Element Thickness	12	mm
Internal Corrosion Allowance	3	mm
Nominal Thickness	12	mm
External Corrosion Allowance	0	mm

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FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

Design Internal Pressure	3.5	kgf/cm ²
Design Temperature Internal Pressure	350	°C
Design External Pressure	1.0546	kgf/cm ²
Design Temperature External Pressure	150	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	[Normalized]
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Platform	
Detail ID	PLAT:[2 OF 2]	
Dist. from "FROM" Node / Offset dist	160	cm
Platform Start Angle (degrees)	0.0	
Platform End Angle (degrees)	360.0	
Platform Wind Area	28800	cm ²
Platform Weight	2701.1	kgf
Platform Railing Weight	0	kgf/cm
Platform Grating Weight	0.017	kgf/cm ²
Platform Width	1200	mm
Platform Height	1000	mm
Platform Clearance or End Offset	100	mm
Platform Force Coefficient	1.2	
Ladder Layout Angle	0.0	
Ladder Start Elevation	0	cm
Ladder End Elevation	500	cm
Unit Weight of Ladder	0.37	kgf/cm
Platform Length (top head platform)	0	mm

Element From Node	40	
Detail Type	Insulation	
Detail ID	Insulation	
Dist. from "FROM" Node / Offset dist	0	cm
Height/Length of Insulation	200	cm
Thickness of Insulation	50	mm
Density	0.0002	kg/cm ³

Element From Node	40	
Detail Type	Ring	
Detail ID	SR 2 Fr 30	
Dist. from "FROM" Node / Offset dist	100	cm
Inside Diameter of Ring	2524	mm
Thickness of Ring	12	mm
Outside Diameter of Ring	2824	mm
Material Name	SA-516 70	[Normalized]
Height of Section Ring	0	mm
Using Custom Stiffener Section	No	

Element From Node	40	
Detail Type	Nozzle	
Detail ID	N4-100-Water Out	
Dist. from "FROM" Node / Offset dist	170	cm
Nozzle Diameter	4	in.
Nozzle Schedule	80	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	14.604	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Input Echo: Step: 1 3:11pm Jul 28,2023

```

-----
Element From Node          50
Element To Node            60
Element Type               Elliptical
Description                Top DEnd
Distance "FROM" to "TO"   5 cm
Inside Diameter           2500 mm
Element Thickness          10 mm
Internal Corrosion Allowance 3 mm
Nominal Thickness          12 mm
External Corrosion Allowance 0 mm
Design Internal Pressure   3.5 kgf/cm²
Design Temperature Internal Pressure 350 °C
Design External Pressure  1.0546 kgf/cm²
Design Temperature External Pressure 150 °C
Effective Diameter Multiplier 1.2
Material Name              SA-516 70 [Normalized]
Efficiency, Longitudinal Seam 1.0
Efficiency, Circumferential Seam 1.0
Elliptical Head Factor     2.0
Weld is pre-Heated         No

```

```

Element From Node          50
Detail Type                Insulation
Detail ID                  Ins: 50
Dist. from "FROM" Node / Offset dist 0 cm
Height/Length of Insulation 67.5 cm
Thickness of Insulation     50 mm
Density                    0.0002 kg/cm³

```

```

Element From Node          50
Detail Type                Nozzle
Detail ID                  N3-600-Steam Out
Dist. from "FROM" Node / Offset dist 0 mm
Nozzle Diameter            24 in.
Nozzle Schedule            None
Nozzle Class               150
Layout Angle               0.0
Blind Flange (Y/N)        N
Weight of Nozzle ( Used if > 0 ) 235.66 kgf
Grade of Attached Flange   GR 1.1
Nozzle Matl                SA-516 70 [Normalized]

```

```

Element From Node          50
Detail Type                Nozzle
Detail ID                  N6-50-PG
Dist. from "FROM" Node / Offset dist 980 mm
Nozzle Diameter            2 in.
Nozzle Schedule            160
Nozzle Class               300
Layout Angle               0.0
Blind Flange (Y/N)        N
Weight of Nozzle ( Used if > 0 ) 5.7148 kgf
Grade of Attached Flange   GR 1.1
Nozzle Matl                SA-106 B

```

```

Element From Node          50
Detail Type                Nozzle
Detail ID                  N8-50-SPARE

```

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Dist. from "FROM" Node / Offset dist	980	mm
Nozzle Diameter	2	in.
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	5.7148	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

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FileName : Decoking Drum_R0-28072023 -----

XY Coordinate Calculations: Step: 2 3:11pm Jul 28,2023

XY Coordinate Calculations:

From	To	X (Horiz.) cm	Y (Vert.) cm	DX (Horiz.) cm	DY (Vert.) cm
Body Flng-N2		...	13.335	...	12.7
ToriCone		...	128.635	...	115.3
Shell-Sec-2		...	328.635	...	200
Shell-Sec-1		...	528.635	...	200
Top DEnd		...	533.635	...	5

PV Elite includes an 1/8 inch (3.175mm) raised face and gasket thicknesses for girth flanges and tubesheet thicknesses where applicable in the Tangent to Tangent length calculation. The calculated dimensions are based on the given element lengths. Due to variability in manufacturing (weld gaps etc.), the Tangent to Tangent length may not be exact.

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FileName : Decoking Drum_R0-28072023 -----

Flg Calc [Int P]: FLANGE Flng: 3 3:11pm Jul 28,2023

Flange Input Data Values

Description: FLANGE :

Body Flng-N2

Flange Type	Integral Weld Neck		
Design Pressure	P	3.84	kgf/cm ²
Design Temperature		350	°C
Internal Corrosion Allowance	ci	3.0000	mm
External Corrosion Allowance	ce	0.0000	mm
Use Corrosion Allowance in Thickness Calcs.		No	
Flange Inside Diameter	B	330.200	mm
Flange Outside Diameter	A	533.400	mm
Flange Thickness	t	35.0520	mm
Thickness of Hub at Small End	go	9.5250	mm
Thickness of Hub at Large End	gl	31.7500	mm
Length of Hub	h	91.9480	mm
Flange Material		SA-105	
Flange Material UNS number		K03504	
Flange Allowable Stress At Temperature	Sfo	1241.39	kgf/cm ²
Flange Allowable Stress At Ambient	Sfa	1406.14	kgf/cm ²
Bolt Material		SA-193 B7	
Bolt Allowable Stress At Temperature	Sb	1757.68	kgf/cm ²
Bolt Allowable Stress At Ambient	Sa	1757.68	kgf/cm ²
Diameter of Bolt Circle	C	476.250	mm
Nominal Bolt Diameter	a	25.4000	mm
Type of Threads	TEMA Thread Series		
Number of Bolts		12	
Flange Face Outside Diameter	Fod	412.750	mm
Flange Face Inside Diameter	Fid	330.200	mm
Flange Facing Sketch	1, Code Sketch 1a		
Gasket Outside Diameter	Go	406.400	mm
Gasket Inside Diameter	Gi	371.602	mm
Gasket Factor	m	0.0000	
Gasket Design Seating Stress	y	0.00	kgf/cm ²
Column for Gasket Seating	2, Code Column II		
Gasket Thickness	tg	3.1750	mm
Flange Class		150	
Flange Grade		GR 1.1	

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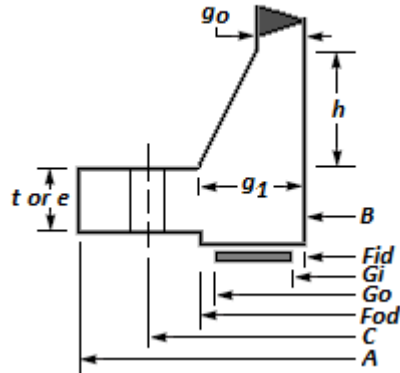
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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Flg Calc [Int P]: FLANGE Flng: 3 3:11pm Jul 28,2023

**ASME Code, Section VIII Division 1, 2021**

Hub Small End Required Thickness due to Internal Pressure:

$$\begin{aligned}
 &= (P * (D/2 + Ca)) / (S * E - 0.6 * P) \text{ per UG-27 (c) (1)} \\
 &= (3.84 * (330.2/2 + 3.0)) / (1241.39 * 1.0 - 0.6 * 3.84) + Ca \\
 &= 3.5215 \text{ mm}
 \end{aligned}$$

Hub Small End Hub MAWP:

$$\begin{aligned}
 &= (S * E * t) / (R + 0.6 * t) \text{ per UG-27 (c) (1)} \\
 &= (1241.39 * 1.0 * 6.525) / (168.1 + 0.6 * 6.525) \\
 &= 47.089 \text{ kgf/cm}^2
 \end{aligned}$$

Corroded Flange ID,	Bcor = B + 2 * Fcor	336.200	mm
Corroded Large Hub,	g1Cor = g1 - ci	28.750	mm
Corroded Small Hub,	g0Cor = go - ci	6.525	mm
Code R Dimension,	R = ((C - Bcor) / 2) - g1cor	41.275	mm
Gasket Contact Width,	N = (Go - Gi) / 2	17.399	mm
Basic Gasket Width,	bo = N / 2	8.699	mm
Effective Gasket Width,	b = Cb * sqrt(bo)	7.432	mm
Gasket Reaction Diameter,	G = Go (Self-Energizing)	406.400	mm

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:

$$\begin{aligned}
 &= 0.785 * G^2 * Peq \\
 &= 0.785 * 406.4^2 * 3.844 \\
 &= 4986.743 \text{ kgf}
 \end{aligned}$$

Contact Load on Gasket Surfaces [Hp]:

$$\begin{aligned}
 &= 2 * b * pi * G * m * P \\
 &= 2 * 7.4325 * pi * 406.4 * 0.0 * 3.84 \\
 &= 0.000 \text{ kgf}
 \end{aligned}$$

Hydrostatic End Load at Flange ID [Hd]:

$$\begin{aligned}
 &= pi * Bcor^2 * P / 4 \\
 &= pi * 336.2^2 * 3.8443 / 4 \\
 &= 3412.754 \text{ kgf}
 \end{aligned}$$

Pressure Force on Flange Face [Ht]:

$$\begin{aligned}
 &= H - Hd \\
 &= 4987 - 3413 \\
 &= 1573.988 \text{ kgf}
 \end{aligned}$$

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FileName : Decoking Drum_R0-28072023 -----

Flg Calc [Int P]: FLANGE Flng: 3 3:11pm Jul 28,2023

Operating Bolt Load [Wm1]:

$$\begin{aligned}
 &= \max(H + H_p + H'p, 0) \\
 &= \max(4987 + 0 + 0, 0) \\
 &= 4986.743 \text{ kgf}
 \end{aligned}$$

Gasket Seating Bolt Load [Wm2]:

$$\begin{aligned}
 &= y * b * \pi * G + y_{Part} * b_{Part} * l_p \\
 &= 0.0 * 7.4325 * \pi * 406.4 + 0.0 * 0.0 * 0.0 \\
 &= 0.000 \text{ kgf}
 \end{aligned}$$

Required Bolt Area [Am]:

$$\begin{aligned}
 &= \max(Wm1/S_b, Wm2/S_a) \\
 &= \max(4987/1758, 0/1758) \\
 &= 2.837 \text{ cm}^2
 \end{aligned}$$

Flange Design Bolt Load, Gasket Seating [W]:

$$\begin{aligned}
 &= S_a (A_m + A_b) / 2 \\
 &= 1757.68 (2.8371 + 42.658) / 2 \\
 &= 39982.75 \text{ kgf}
 \end{aligned}$$

Gasket Load for the Operating Condition [HG]:

$$\begin{aligned}
 &= Wm1 - H \\
 &= 4987 - 4987 \\
 &= 0.00 \text{ kgf}
 \end{aligned}$$

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:

$$\begin{aligned}
 &= (C - G) / 2 \\
 &= (476.25 - 406.4) / 2 \\
 &= 34.9250 \text{ mm}
 \end{aligned}$$

Distance to Face Pressure Reaction [ht]:

$$\begin{aligned}
 &= (R + g_1 + h_g) / 2 \\
 &= (41.275 + 28.75 + 34.925) / 2 \\
 &= 52.4750 \text{ mm}
 \end{aligned}$$

Distance to End Pressure Reaction [hd]:

$$\begin{aligned}
 &= R + (g_1 / 2) \\
 &= 41.275 + (28.75 / 2.0) \\
 &= 55.6500 \text{ mm}
 \end{aligned}$$

Summary of Moments for Internal Pressure: (kgf-m.)

Loading		Force	Distance	Bolt Corr	Moment
End Pressure,	Md	3413.	55.6500	1.1982	228.
Face Pressure,	Mt	1574.	52.4750	1.1982	99.
Gasket Load,	Mg	0.	34.9250	1.1982	0.
Gasket Seating,	Matm	39983.	34.9250	1.1982	1673.
Total Moment for Operation, Mop					327. kgf-m.
Total Moment for Gasket seating, Matm					1673. kgf-m.

*You chose not to perform Stress Calculations on this Standard Flange.
The pressure rating of the flange will be used to check code compliance.*

Estimated Finished Weight of Flange at given Thk. 53.7 kg
Estimated Unfinished Weight of Forging at given Thk 135.7 kg

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Flg Calc [Int P]: FLANGE Flng: 3 3:11pm Jul 28,2023

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b)	-104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $3.84/19.99 = 0.192$

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FileName : Decoking Drum_R0-28072023 -----

Internal Pressure Calculations: Step: 4 3:11pm Jul 28,2023

Internal Pressure Results Summary:**Element Thickness, Pressure, Diameter and Allowable Stress :**

From	To	Int. Press + Liq. Hd kgf/cm ²	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress (SE) kgf/cm ²
Body Flng-N2		3.8443	12	3	330.2	1241.4
ToriCone		3.8443	12	3	2433	1310
Shell-Sec-2		3.6599	12	3	2500	1310
Shell-Sec-1		3.5	12	3	2500	1310
Top DEnd		3.5	12	3	2500	1310

Element Required Thickness and MAWP :

From	To	Design Pressure kgf/cm ²	M.A.W.P. Corroded kgf/cm ²	M.A.P. New & Cold kgf/cm ²	Minimum Thickness mm	Required Thickness mm
Body Flng-N2		3.5	8.22155	19.987	35.052	No Calc
ToriCone		3.5	7.23437	10.9598	11	6.96382
Shell-Sec-2		3.5	9.2092	13.4216	12	6.50653
Shell-Sec-1		3.5	9.36913	13.4216	12	6.35305
Top DEnd		3.5	7.33775	11.2401	10	6.33792
Minimum			5	11		

MAWP: 5 kgf/cm², limited by: Nozzle Reinforcement.

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:**ASME Code, Section VIII Division 1, 2021****Conical Section From 20 To 30 SA-516 70 , UCS-66 Crv. D at 350 °C**

ToriCone

Longitudinal Joint: User Defined

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot D) / (2 \cdot \cos(a) \cdot (S \cdot E - 0.6 \cdot P)) \text{ per Appendix 1-4 (e)} \\
 &= (3.68 \cdot 2439.9409) / (2 \cdot 0.866 \cdot (1310.01 \cdot 1.0 - 0.6 \cdot 3.68)) \\
 &= 3.9638 + 3.0000 = 6.9638 \text{ mm}
 \end{aligned}$$

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

Less Operating Hydrostatic Head Pressure of 0.180 kgf/cm²

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t \cdot \cos(a)) / (D + 1.2 \cdot t \cdot \cos(a)) \text{ per App 1-4 (e)} \\
 &= (2 \cdot 1310.01 \cdot 1.0 \cdot 8.0 \cdot 0.866) / (2439.941 + 1.2 \cdot 8.0 \cdot 0.866) \\
 &= 7 - 0 = 7 \text{ kgf/cm}^2
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t \cdot \cos(a)) / (D + 1.2 \cdot t \cdot \cos(a)) \text{ per App 1-4 (e)} \\
 &= (2 \cdot 1406.14 \cdot 1.0 \cdot 11.0 \cdot 0.866) / (2433.0127 + 1.2 \cdot 11.0 \cdot 0.866)
 \end{aligned}$$

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$$= 11 \text{ kgf/cm}^2$$

Actual stress at given pressure and thickness, corroded [Sact]:

$$= (P * (D + 1.2 * t * \cos(a))) / (2 * E * t * \cos(a))$$

$$= (3.68 * (2439.9409 + 1.2 * 8.0 * 0.866)) / (2 * 1.0 * 8.0 * 0.866)$$

$$= 650.196 \text{ kgf/cm}^2$$

Thickness and Maximum Pressure for Large Knuckle:

Equivalent Crown Radius for the Cone Large End Knuckle [L]:

$$= Di / (2 * (\cos(\alpha)) + ca) \text{ per UG-32 (h)}$$

$$= 2433.01 / (2 * (\cos(30.0)) + 3.0)$$

$$= 1407.701 \text{ mm}$$

Stress Concentration Factor [M]:

$$= (3 + \sqrt{L / (r + ca)}) / 4$$

$$= (3 + \sqrt{250.0 / (250.0 + 3.0)}) / 4$$

$$= 1.340$$

Required Knuckle Thickness due to Internal Pressure [Tr_Knuckle]:

$$= (P(L + ca)M) / (2 * S * E - 0.2 * P) + ca \text{ per App. 1-4 (d)}$$

$$= (3.68(1407.7006)1.34) / (2 * 1310 * 1.0 - 0.2 * 3.68) + 3.0$$

$$= 5.655 \text{ mm}$$

Large End Knuckle Maximum Allowable Working Pressure [Knuckle_MAWP]:

Less Operating Hydrostatic Head Pressure of 0.180 kgf/cm²

$$= (2 * S * E * (t - ca)) / (M(L + ca) + 0.2(t - ca)) \text{ per Appendix 1-4 (d)}$$

$$= (2 * 1310 * 1.0(12.0 - 3.0)) / (1.34(1407.7006 + 3.0) + 0.2(12.0 - 3.0))$$

$$= 12 - 0 = 12 \text{ kgf/cm}^2$$

Minimum Knuckle Radius check per Figure UG-36 [rL]:

$$= \max(3 * t, 0.12(RL + t))$$

$$= \max(3 * 8.0, 0.12(1253.0 + 8.0))$$

$$= 151.32 \text{ mm}$$

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 3.248 %

Note: The Pressure at the Large Diameter is used in the TR calculation.

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 11.0, tr = 4.887, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.611, Temp. Reduction = 22 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Cylindrical Shell From 30 To 40 SA-516 70 , UCS-66 Crv. D at 350 °C

Shell-Sec-2

Longitudinal Joint: User Defined

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$= (P * R) / (S * E - 0.6 * P) \text{ per UG-27 (c) (1)}$$

$$= (3.66 * 1253.0) / (1310.01 * 1.0 - 0.6 * 3.66)$$

$$= 3.5065 + 3.0000 = 6.5065 \text{ mm}$$

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

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Less Operating Hydrostatic Head Pressure of 0.160 kgf/cm²

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (1310.01 \cdot 1.0 \cdot 9.0) / (1253.0 + 0.6 \cdot 9.0) \\
 &= 9 - 0 = 9 \text{ kgf/cm}^2
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (1406.14 \cdot 1.0 \cdot 12.0) / (1250.0 + 0.6 \cdot 12.0) \\
 &= 13 \text{ kgf/cm}^2
 \end{aligned}$$

Actual stress at given pressure and thickness, corroded [Sact]:

$$\begin{aligned}
 &= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t) \\
 &= (3.66 \cdot (1253.0 + 0.6 \cdot 9.0)) / (1.0 \cdot 9.0) \\
 &= 511.739 \text{ kgf/cm}^2
 \end{aligned}$$

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.478 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 12.0, tr = 4.329, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.481, Temp. Reduction = 35 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Cylindrical Shell From 40 To 50 SA-516 70 , UCS-66 Crv. D at 350 °C**Shell-Sec-1**

Longitudinal Joint: User Defined

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot R) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= (3.5 \cdot 1253.0) / (1310.01 \cdot 1.0 - 0.6 \cdot 3.5) \\
 &= 3.3531 + 3.0000 = 6.3531 \text{ mm}
 \end{aligned}$$

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (1310.01 \cdot 1.0 \cdot 9.0) / (1253.0 + 0.6 \cdot 9.0) \\
 &= 9 \text{ kgf/cm}^2
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (1406.14 \cdot 1.0 \cdot 12.0) / (1250.0 + 0.6 \cdot 12.0) \\
 &= 13 \text{ kgf/cm}^2
 \end{aligned}$$

Actual stress at given pressure and thickness, corroded [Sact]:

$$\begin{aligned}
 &= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t) \\
 &= (3.5 \cdot (1253.0 + 0.6 \cdot 9.0)) / (1.0 \cdot 9.0) \\
 &= 489.378 \text{ kgf/cm}^2
 \end{aligned}$$

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.478 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 12.0, tr = 4.186, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.465, Temp. Reduction = 37 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

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Internal Pressure Calculations: Step: 4 3:11pm Jul 28,2023

Elliptical Head From 50 To 60 SA-516 70 , UCS-66 Crv. D at 350 °C

Top DEnd

Longitudinal Joint: User Defined

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot D \cdot K_{cor}) / (2 \cdot S \cdot E - 0.2 \cdot P) \text{ Appendix 1-4 (c)} \\
 &= (3.5 \cdot 2506.0 \cdot 0.997) / (2 \cdot 1310.01 \cdot 1.0 - 0.2 \cdot 3.5) \\
 &= 3.3379 + 3.0000 = 6.3379 \text{ mm}
 \end{aligned}$$

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t) / (K_{cor} \cdot D + 0.2 \cdot t) \text{ per Appendix 1-4 (c)} \\
 &= (2 \cdot 1310.01 \cdot 1.0 \cdot 7.0) / (0.997 \cdot 2506.0 + 0.2 \cdot 7.0) \\
 &= 7 \text{ kgf/cm}^2
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t) / (K \cdot D + 0.2 \cdot t) \text{ per Appendix 1-4 (c)} \\
 &= (2 \cdot 1406.14 \cdot 1.0 \cdot 10.0) / (1.0 \cdot 2500.0 + 0.2 \cdot 10.0) \\
 &= 11 \text{ kgf/cm}^2
 \end{aligned}$$

Actual stress at given pressure and thickness, corroded [Sact]:

$$\begin{aligned}
 &= (P \cdot (K_{cor} \cdot D + 0.2 \cdot t)) / (2 \cdot E \cdot t) \\
 &= (3.5 \cdot (0.997 \cdot 2506.0 + 0.2 \cdot 7.0)) / (2 \cdot 1.0 \cdot 7.0) \\
 &= 624.857 \text{ kgf/cm}^2
 \end{aligned}$$

Straight Flange Required Thickness:

$$\begin{aligned}
 &= (P \cdot R) / (S \cdot E - 0.6 \cdot P) + c \text{ per UG-27 (c) (1)} \\
 &= (3.5 \cdot 1253.0) / (1310.01 \cdot 1.0 - 0.6 \cdot 3.5) + 3.0 \\
 &= 6.353 \text{ mm}
 \end{aligned}$$

Straight Flange Maximum Allowable Working Pressure:

$$\begin{aligned}
 &= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c) (1)} \\
 &= (1310.01 \cdot 1.0 \cdot 9.0) / (1253.0 + 0.6 \cdot 9.0) \\
 &= 9 \text{ kgf/cm}^2
 \end{aligned}$$

Factor K, corroded condition [Kcor]:

$$\begin{aligned}
 &= (2 + (\text{Inside Diameter} / (2 \cdot \text{Inside Head Depth}))^2) / 6 \\
 &= (2 + (2506.0 / (2 \cdot 628.0))^2) / 6 \\
 &= 0.996819
 \end{aligned}$$

Percent Elong. per UCS-79, VIII-1-01-57 $(75 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$ 2.088 %**MDMT Calculations in the Knuckle Portion:**

Govrn. thk, tg = 10.0, tr = 4.165, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr \cdot E^* / (tg - c) = 0.595$, Temp. Reduction = 23 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 12.0, tr = 4.186, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr \cdot E^* / (tg - c) = 0.465$, Temp. Reduction = 37 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

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Internal Pressure Calculations: Step: 4 3:11pm Jul 28,2023

Hydrostatic Test Pressure Results:

Pressure per UG99b	= 1.30 * M.A.W.P. * Sa/S	6.224	kgf/cm ²
Pressure per UG99b[35]	= 1.30 * Design Pres * Sa/S	4.647	kgf/cm ²
Pressure per UG99c	= 1.30 * M.A.P. - Head(Hyd)	13.998	kgf/cm ²
Pressure per UG100	= 1.10 * M.A.W.P. * Sa/S	5.266	kgf/cm ²
Pressure per PED	= max(1.43*DP, 1.25*DP*ratio)	5.005	kgf/cm ²
Pressure per App 27-4	= M.A.W.P.	4.688	kgf/cm ²

Horizontal Test performed per: UG-99c

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (kgf/ cm²):

From To	Stress	Allowable	Ratio	Pressure
ToriCone	1827.1	1828.0	1.000	14.24
Shell-Sec-2	1492.7	1828.0	0.817	14.25
Shell-Sec-1	1492.7	1828.0	0.817	14.25
Top DEnd	1782.4	1828.0	0.975	14.25

Stress ratios for Nozzle and Pad Materials (kgf/ cm²):

Description	Pad/Nozzle	Ambient	Operating	Ratio
N5-100-SEAL	Nozzle	1202.20	1177.10	1.021
N5-100-SEAL	Pad	1406.14	1310.01	1.073
M-600-MH	Nozzle	1406.10	1310.00	1.073
M-600-MH	Pad	1406.10	1310.00	1.073
N7-50-Temp Gauge	Nozzle	1202.20	1177.10	1.021
N1-600-Vapour Ou	Nozzle	1406.10	1310.00	1.073
N1-600-Vapour Ou	Pad	1406.10	1310.00	1.073
N4-100-Water Out	Nozzle	1202.20	1177.10	1.021
N4-100-Water Out	Pad	1406.14	1310.01	1.073
N3-600-Steam Out	Nozzle	1406.10	1310.00	1.073
N3-600-Steam Out	Pad	1406.10	1310.00	1.073
N6-50-PG	Nozzle	1202.20	1177.10	1.021
N8-50-SPARE	Nozzle	1202.20	1177.10	1.021

Minimum	1.021
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Stress ratios for Stiffening Ring Materials (kgf/ cm²):

Description	Ambient	Operating	Ratio
SR 1 Fr 20	1406.14	1310.01	1.073
SR 2 Fr 30	1406.14	1310.01	1.073

Minimum	1.073
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Stress ratios for Pressurized Vessel Elements (kgf/ cm²):

Description	Ambient	Operating	Ratio
Body Flng-N2	1406.14	1241.39	1.133
ToriCone	1406.14	1310.01	1.073

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Internal Pressure Calculations: Step: 4 3:11pm Jul 28,2023

Shell-Sec-2	1406.14	1310.01	1.073
Shell-Sec-1	1406.14	1310.01	1.073
Top DEnd	1406.14	1310.01	1.073

Minimum			1.073

Hoop Stress in Nozzle Wall during Pressure Test (kgf/ cm²):

Description	Ambient	Operating	Ratio

N5-100-SEAL	89.38	1562.90	0.057
M-600-MH	356.19	1828.00	0.195
N7-50-Temp Gauge	43.48	1562.90	0.028
N1-600-Vapour Ou	356.19	1828.00	0.195
N4-100-Water Out	89.43	1562.90	0.057
N3-600-Steam Out	356.19	1828.00	0.195
N6-50-PG	43.48	1562.90	0.028
N8-50-SPARE	43.48	1562.90	0.028

Elements Suitable for Test Pressure.

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External Pressure Calculations: Step: 5 3:11pm Jul 28,2023

External Pressure Calculation Results :**External Pressure Calculations:**

From	To	Section Length cm	Outside Diameter mm	Corroded Thickness mm	Factor A	Factor B kgf/cm ²
10	20	No Calc	...	32.052	No Calc	No Calc
20	30	167.3	2451.8	8	0.00036838	375.288
30	Ring	167.3	2524	9	0.00043574	443.917
Ring	40	248	2524	9	0.00028877	294.191
40	Ring	248	2524	9	0.00028877	294.191
Ring	50	125.833	2524	9	0.00058894	599.984
50	60	No Calc	2520	7	0.0003858	393.039

External Pressure Calculations:

From	To	External Actual T. mm	External Required T. mm	External Design Pressure kgf/cm ²	External M.A.W.P. kgf/cm ²
10	20	35.052	No Calc	1.05461	No Calc
20	30	11	9.69043	1.05461	1.63271
30	Ring	12	9.80819	1.05461	2.11054
Ring	40	12	11.038	1.05461	1.39869
40	Ring	12	11.038	1.05461	1.39869
Ring	50	12	9.07139	1.05461	2.85254
50	60	10	9.52698	1.05461	1.21308

Minimum

1

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners cm	Allowable Length Bet. Stiffeners cm	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	167.3	254.166	No Calc	No Calc
30	Ring	167.3	325.324	No Calc	No Calc
Ring	40	248	325.368	237.097	854.132
40	Ring	248	325.368	No Calc	No Calc
Ring	50	125.833	325.419	213.327	854.132
50	60	No Calc	No Calc	No Calc	No Calc

[Elements Suitable for External Pressure.](#)**ASME Code, Section VIII Division 1, 2021****Cylindrical Shell From 20 to 30 Ext. Chart: CS-2 at 150 °C**[ToriCone](#)Elastic Modulus from Chart: CS-2 at 150 °C: 2037513 kgf/cm²

Results for Maximum Allowable Ext. Pressure

MAEP

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

External Pressure Calculations: Step: 5 3:11pm Jul 28,2023

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
8.000	2451.80	1673.00	306.47	0.6824	0.0003684	375.29

$$MAEP = (4*B) / (3*(Do/t)) = (4*375.2878) / (3*306.4747) = 1.6327 \text{ kgf/cm}^2$$

Results for Required Thickness	Tca
--------------------------------	-----

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
6.690	2451.80	1673.00	366.46	0.6824	0.0002845	289.87

$$MAEP = (4*B) / (3*(Do/t)) = (4*289.8662) / (3*366.4633) = 1.0546 \text{ kgf/cm}^2$$

Results for Maximum Stiffened Length	Slen
--------------------------------------	------

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
8.000	2451.80	2541.66	306.47	1.0366	0.0002381	242.55

$$MAEP = (4*B) / (3*(Do/t)) = (4*242.5525) / (3*306.4747) = 1.0552 \text{ kgf/cm}^2$$

Cylindrical Shell From 30 to SR 1 Fr 20 Ext. Chart: CS-2 at 150 °C**Shell-Sec-2**Elastic Modulus from Chart: CS-2 at 150 °C: 2037513 kgf/cm²

Results for Maximum Allowable Ext. Pressure	MAEP
---	------

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
9.000	2524.00	1673.00	280.44	0.6628	0.0004357	443.92

$$MAEP = (4*B) / (3*(Do/t)) = (4*443.917) / (3*280.4445) = 2.1105 \text{ kgf/cm}^2$$

Results for Required Thickness	Tca
--------------------------------	-----

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
6.808	2524.00	1673.00	370.73	0.6628	0.0002878	293.24

$$MAEP = (4*B) / (3*(Do/t)) = (4*293.2445) / (3*370.7301) = 1.0547 \text{ kgf/cm}^2$$

Results for Maximum Stiffened Length	Slen
--------------------------------------	------

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
9.000	2524.00	3253.24	280.44	1.2889	0.0002179	222.03

$$MAEP = (4*B) / (3*(Do/t)) = (4*222.0313) / (3*280.4445) = 1.0556 \text{ kgf/cm}^2$$

Cylindrical Shell From SR 1 Fr 20 to 40 Ext. Chart: CS-2 at 150 °C**Shell-Sec-2**Elastic Modulus from Chart: CS-2 at 150 °C: 2037513 kgf/cm²

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FileName : Decoking Drum_R0-28072023 -----

External Pressure Calculations: Step: 5 3:11pm Jul 28,2023

Results for Maximum Allowable Ext. Pressure						MAEP	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
9.000	2524.00	2480.00	280.44	0.9826	0.0002888	294.19	

$$MAEP = (4*B)/(3*(Do/t)) = (4*294.1907)/(3*280.4445) = 1.3987 \text{ kgf/cm}^2$$

Results for Required Thickness						Tca	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
8.038	2524.00	2480.00	314.01	0.9826	0.0002438	248.38	

$$MAEP = (4*B)/(3*(Do/t)) = (4*248.3766)/(3*314.0102) = 1.0546 \text{ kgf/cm}^2$$

Results for Maximum Stiffened Length						Slen	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
9.000	2524.00	3253.68	280.44	1.2891	0.0002179	222.00	

$$MAEP = (4*B)/(3*(Do/t)) = (4*222.0003)/(3*280.4445) = 1.0555 \text{ kgf/cm}^2$$

Cylindrical Shell From 40 to SR 2 Fr 30 Ext. Chart: CS-2 at 150 °C**Shell-Sec-1**Elastic Modulus from Chart: CS-2 at 150 °C: 2037513 kgf/cm²

Results for Maximum Allowable Ext. Pressure						MAEP	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
9.000	2524.00	2480.00	280.44	0.9826	0.0002888	294.19	

$$MAEP = (4*B)/(3*(Do/t)) = (4*294.1907)/(3*280.4445) = 1.3987 \text{ kgf/cm}^2$$

Results for Required Thickness						Tca	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
8.038	2524.00	2480.00	314.01	0.9826	0.0002438	248.38	

$$MAEP = (4*B)/(3*(Do/t)) = (4*248.3766)/(3*314.0102) = 1.0546 \text{ kgf/cm}^2$$

Results for Maximum Stiffened Length						Slen	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
9.000	2524.00	3253.68	280.44	1.2891	0.0002179	222.00	

$$MAEP = (4*B)/(3*(Do/t)) = (4*222.0003)/(3*280.4445) = 1.0555 \text{ kgf/cm}^2$$

Cylindrical Shell From SR 2 Fr 30 to 50 Ext. Chart: CS-2 at 150 °C**Shell-Sec-1**Elastic Modulus from Chart: CS-2 at 150 °C: 2037513 kgf/cm²

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FileName : Decoking Drum_R0-28072023 -----

External Pressure Calculations: Step: 5 3:11pm Jul 28,2023

Results for Maximum Allowable Ext. Pressure						MAEP	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
9.000	2524.00	1258.33	280.44	0.4985	0.0005889	599.98	

$$MAEP = (4*B)/(3*(Do/t)) = (4*599.9838)/(3*280.4445) = 2.8525 \text{ kgf/cm}^2$$

Results for Required Thickness						Tca	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
6.071	2524.00	1258.33	415.72	0.4985	0.0003228	328.84	

$$MAEP = (4*B)/(3*(Do/t)) = (4*328.8377)/(3*415.7205) = 1.0547 \text{ kgf/cm}^2$$

Results for Maximum Stiffened Length						Slen	
Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B	
9.000	2524.00	3254.19	280.44	1.2893	0.0002179	221.96	

$$MAEP = (4*B)/(3*(Do/t)) = (4*221.9639)/(3*280.4445) = 1.0553 \text{ kgf/cm}^2$$

Elliptical Head From 50 to 60 Ext. Chart: CS-2 at 150 °C

Top DEnd

Elastic Modulus from Chart: CS-2 at 150 °C: 2037513 kgf/cm²

Results for Maximum Allowable Ext. Pressure					MAEP	
Tca	Outer Dia	Do/t	Factor A		Factor B	
7.000	2520.00	360.00	0.0003858		393.04	

$$MAEP = B/(K0*Do/t) = 393.0389/(0.9 * 360.0) = 1.2131 \text{ kgf/cm}^2$$

Results for Required Thickness					Tca	
Tca	Outer Dia	Do/t	Factor A		Factor B	
6.527	2520.00	386.09	0.0003597		366.48	

$$MAEP = B/(K0*Do/t) = 366.4794/(0.9 * 386.09) = 1.0547 \text{ kgf/cm}^2$$

Stiffening Ring Calcs for: SR 1 Fr 20, SA-516 70 , Bar Ring: 150 x 12 mm

Effective Length of Shell: 166 mm

	Area (cm ²)	Distance (mm)	Area*Dist
Shell:	14.921	4.5000	67.145
Ring :	18.000	84.0000	1512.001
Total:	32.921		1579.146

Centroid of Ring plus Shell: 48 mm

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FileName : Decoking Drum_R0-28072023 -----

External Pressure Calculations: Step: 5 3:11pm Jul 28,2023

	Inertia	Distance	A*Dist ²
Shell:	1.007	43.4676	28192.391
Ring :	337.500	-36.0325	23370.090
Total:	338.508		51562.480

Available Moment of Inertia, Ring + Shell: 0.854E+03 cm**4

Required Stress in Ring plus Shell Breq 202.33 kgf/cm²
 Required Strain in Ring plus Shell Areq 0.0001980

Required Moment of Inertia, Ring plus Shell:

$$= (OD^2 * Slen(Tca + Aring/Slen)Areq) / 10.9$$

$$= (2524.0002^2 * 2076.5 (9.0 + 18.0 / 2076.5) 0.000198) / 10.9$$

$$= 237 \text{ cm**4}$$

Results for Stiffening Ring Weld Calculations per UG-30:

Given Stiffening Ring Fillet Weld Size	Wleg	8.000	mm
Stiffening Ring Attachment Style		CONTINUOUS	
Location of Stiffening Ring		EXTERNAL	
Radial Pressure Load	Pext*Slen	21.90	kgf/mm
The Radial Shear Load	V	552.73	kgf
The First Moment of the Area (Ring + Shell)	Q	64858.44	mm ³
Weld Shear Flow due to Rad. Shear Load	VQ/I	4.20	kgf/mm
The Weld Allowable Stress	0.55*S	773.38	kgf/cm ²
Minimum Weld Leg Size Min(6mm, t, tw)	Wldmin	6.00	mm
The Weld Allowable Load	2* WLeg*0.55*S	123.74	kgf/mm
The Combined Weld Load	SRSS of VQ/I and Pext*Slen	22.30	kgf/mm

MDMT Calculations for: SR 1 Fr 20, Shell to Ring Junction, Curve: D

Govrn. thk, tg = 12.0, tr = 4.329, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.481, Temp. Reduction = 35 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

Stiffening Ring Calcs for: SR 2 Fr 30, SA-516 70 , Bar Ring: 150 x 12 mm

Effective Length of Shell: 166 mm

	Area (cm ²)	Distance (mm)	Area*Dist
Shell:	14.921	4.5000	67.145
Ring :	18.000	84.0000	1512.001
Total:	32.921		1579.146

Centroid of Ring plus Shell: 48 mm

	Inertia	Distance	A*Dist ²
Shell:	1.007	43.4676	28192.391
Ring :	337.500	-36.0325	23370.090
Total:	338.508		51562.480

Available Moment of Inertia, Ring + Shell: 0.854E+03 cm**4

Required Stress in Ring plus Shell Breq 200.38 kgf/cm²
 Required Strain in Ring plus Shell Areq 0.0001960

Required Moment of Inertia, Ring plus Shell:

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External Pressure Calculations: Step: 5 3:11pm Jul 28,2023

$$= (OD^2 * Slen(Tca + Aring/Slen)Areq) / 10.9$$

$$= (2524.0002^2 * 1869.1667(9.0 + 18.0/1869.1667)0.000196) / 10.9$$

$$= 213 \text{ cm}^4$$

Results for Stiffening Ring Weld Calculations per UG-30:

Given Stiffening Ring Fillet Weld Size	Wleg	8.000	mm
Stiffening Ring Attachment Style	CONTINUOUS		
Location of Stiffening Ring	EXTERNAL		
Radial Pressure Load	Pext*Slen	19.71	kgf/mm
The Radial Shear Load	V	497.54	kgf
The First Moment of the Area (Ring + Shell)	Q	64858.44	mm ³
Weld Shear Flow due to Rad. Shear Load	VQ/I	3.78	kgf/mm
The Weld Allowable Stress	0.55*S	773.38	kgf/cm ²
Minimum Weld Leg Size Min(6mm, t, tw)	Wldmin	6.00	mm
The Weld Allowable Load	2* Wleg*0.55*S	123.74	kgf/mm
The Combined Weld Load	SRSS of VQ/I and Pext*Slen	20.07	kgf/mm

MDMT Calculations for: SR 2 Fr 30, Shell to Ring Junction, Curve: D-----
Govrn. thk, tg = 12.0, tr = 4.186, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.465, Temp. Reduction = 37 °C

Min Metal Temp. w/o impact per UCS-66, Curve D -48 °C

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DECOKING DRUM

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FileName : Decoking Drum_R0-28072023 -----

Element and Detail Weights: Step: 6 3:11pm Jul 28,2023

Element and Detail Weights:

From	To	Element Metal Wgt. kg	Element ID Volume cm ³	Corroded Metal Wgt. kg	Corroded ID Volume cm ³	Extra due Misc % kg
10	20	53.652	10985.5	50.561	11274.3	...
20	30	627.786	2691819	508.278	2707239	...
30	40	1467.92	9817479	1102.26	9864659	...
40	50	1467.92	9817479	1102.26	9864659	...
50	60	739.096	2290744	554.322	2306686	...
Total		4356	24628510.00	3317	24754518.00	0

Weight of Details:

From	Type	Weight of Detail kg	X Offset, Dtl. Cent. cm	Y Offset, Dtl. Cent. cm	Z Offset Dtl. Cent. cm	Description
10	Ins1	2.43761	...	6.35	...	Ins: 10
20	Liqd	4304.99	...	57.65	...	Liquid: 20
20	Ins1	75.5129	...	57.65	...	Ins: 20
20	Noz1	16.5629	77.445	75.3	77.445	N5-100-SEAL
30	Plat	2516.08	0.17812E-05	50	...	PLAT:[1 OF 2]
30	Liqd	7850.47	...	50	...	Liquid: 30
30	Ins1	161.916	...	100	...	Ins: 30
30	Ring	117.194	...	52	...	SR 1 Fr 20
30	Noz1	428.045	132.501	120	...	M-600-MH
30	Noz1	4.55389	132.501	40	...	N7-50-Temp Gauge
30	Noz1	365.817	...	140	-132.501	N1-600-Vapour Ou
30	Legs	832.446	...	-150.5	...	LEGS
40	Plat	2701.08	0.17812E-05	160	...	PLAT:[2 OF 2]
40	Ins1	161.916	...	100	...	Insulation
40	Ring	117.194	...	100	...	SR 2 Fr 30
40	Noz1	14.6035	132.501	170.001	...	N4-100-Water Out
50	Ins1	97.755	...	33.75	...	Ins: 50
50	Noz1	235.665	...	74.5006	...	N3-600-Steam Out
50	Noz1	5.7148	98	50.7982	...	N6-50-PG
50	Noz1	5.7148	-98	50.7982	...	N8-50-SPARE

Total Weight of Each Detail Type:

Platforms	5217.2
Liquid	12155.5
Insulation	499.5
Stiffeners	234.4
Nozzles	1076.7
Legs	832.4
Sum of the Detail Weights	
	20015.7 kg

Weight Summation Results: (kg)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	4356.4	4356.4	4356.4	4356.4	4356.4	4356.4
Stif. Rings	234.4	234.4	234.4	234.4	234.4	234.4
Nozzles	1076.7	1076.7	1076.7	1076.7	1076.7	1076.7

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FileName : Decoking Drum_R0-28072023 -----

Element and Detail Weights: Step: 6 3:11pm Jul 28,2023

Legs	832.4	832.4	832.4	832.4	832.4	832.4
Platforms	...	...	...	5217.2	5217.2	5217.2
Insulation	...	...	...	499.5	499.5	499.5
Ope. Liquid	...	...	...	...	...	12155.5
Test Liquid	...	24617.5	...	...	...	...
Totals	6499.9	31117.3	6499.9	12216.6	12216.6	24372.1

Field Installation Options:

Platforms installed before lifting.

Insulation installed before lifting.

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	6499.9 kg
Shop Test Wt.	- Fabricated Weight + Water (Full)	31117.3 kg
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	6499.9 kg
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	12216.6 kg
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	12216.6 kg
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	24372.1 kg
Field Test Wt.	- Empty Weight + Water (Full)	36834.0 kg

Weights used in Vortex Shedding Calculations:

Mass of the Upper 1/3 of the Vertical Vessel (operating)	4824.8 kg
Mass of the Upper 1/3 of the Vertical Vessel (filled w/water)	14869.3 kg
Mass of the Upper 1/3 of the Vertical Vessel (empty)	5325.6 kg

Outside Surface Areas of Elements:

From	To	Surface Area cm ²
10	20	3102.87
20	30	64793.8
30	40	158588
40	50	158588
50	60	73020.8
Total		458092.750 cm ²

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kg	Total. Ele. Oper. Wgt. kg	Total. Ele. Hydro. Wgt. kg	Total Dtl. Offset Mom. kgf-m.	Oper. Wgt. No Liquid kg
10	20	53.652	56.0896	67.0702	...	56.0896
20	30	644.348	5024.85	3410.47	12.8272	719.861
30	Legs	381.366	2065.92	2379.94	573.197	809.845
Legs	40	2002.17	10846.1	12494.7	...	4251.69
40	50	1599.72	4462.72	14275.8	19.3498	4462.72
50	60	986.191	1083.95	3373.66	...	1083.95

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg	Cumulative Oper. Wgt. kg	Cumulative Hydro. Wgt. kg
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FileName : Decoking Drum_R0-28072023 -----

Element and Detail Weights: Step: 6 3:11pm Jul 28,2023

10	20	...	...	...
20	30	-56.0896	-56.0896	-67.0702
30	Legs	-775.951	-5080.94	-3477.54
Legs	40	9798.35	16392.7	30144.1
40	50	5546.66	5546.66	17649.5
50	60	1083.95	1083.95	3373.66

The cumulative operating weights no liquid in the column above are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. kgf-m.	Cumulative Oper. Mom. kgf-m.	Cumulative Hydro. Mom. kgf-m.
10	20	...	...	...
20	30	12.8272	12.8272	12.8272
30	Legs	586.024	586.024	586.024
Legs	40	19.3498	19.3498	19.3498
40	50	19.3498	19.3498	19.3498
50	60	...	...	...

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Flange MAWP: Step: 7 3:11pm Jul 28,2023

Nozzle Flange MAWP Results: (kgf/cm² & °C)

Nozzle Description	Flange Rating		Design Temp	Class	Grade/ Group	Equiv. Press	Max Pressure		
	Ope.	Ambient					UG-44 (b)	50%	DNV
N5-100-SEAL	8.57	19.99	350	150	GR 1.1	...	...	...	...
M-600-MH	8.57	19.99	350	150	GR 1.1	...	...	...	...
N7-50-Temp Gau	38.34	52.11	350	300	GR 1.1	...	...	...	...
N1-600-Vapour	38.34	52.11	350	300	GR 1.1	...	...	...	...
N4-100-Water O	8.57	19.99	350	150	GR 1.1	...	...	...	...
N3-600-Steam O	8.57	19.99	350	150	GR 1.1	...	...	...	...
N6-50-PG	38.34	52.11	350	300	GR 1.1	...	...	...	...
N8-50-SPARE	8.57	19.99	350	150	GR 1.1	...	...	...	...
Min Rating	8.566	19.987	kgf/cm ² [for Core Element s]				...	...	...

Pressure Ratings are per ASME B16.5 2017 Metric Edition

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FileName : Decoking Drum_R0-28072023 -----

Natural Frequency Calculation: Step: 8 3:11pm Jul 28,2023

The Natural Frequencies for the vessel have been computed iteratively by solving a system of matrices. These matrices describe the mass and the stiffness of the vessel. This is the generalized eigenvalue/eigenvector problem and is referenced in some mathematical texts.

The Natural Frequency for the Vessel (Empty.) is 11.0338 Hz.

The Natural Frequency for the Vessel (Ope...) is 9.01403 Hz.

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FileName : Decoking Drum_R0-28072023 -----

Wind Load Calculation: Step: 9 3:11pm Jul 28,2023

Wind Load Calculation Results:**Wind Load Calculations per India Std. IS 875 (PART 3):2015, Amd. 1&2 (2020):****Input Values:**

Wind Design Code	IS 875 (PART 3):2015-2020	
Basic Wind Speed for IS-875	169.2	km/hr
Wind Zone Number	1	
Base Elevation	30	cm
Percent Wind for Hydrotect	33.0	
Risk Factor	[k1] 1.0	
Terrain Category	2	
Equipment Class	Class A	
Topography Factor	[k3] 1.0	
Importance Factor	[k4] 1.0	
Damping Factor (Beta) for Wind (Ope)	0.0100	
Damping Factor (Beta) for Wind (Empty)	0.0000	
Damping Factor (Beta) for Wind (Filled)	0.0000	
Use Gust Response Factor (Dynamic Analysis)	No	

Calculated Values:

Vessel Height to Diameter ratio: 2.577

Checking the requirement for dynamic effect of wind (9.1):

Vessel Operating Natural Frequency: 9.014 Hz

Note: Vessel Natural frequency is ≥ 1 Hz.Note: Vessel height to diameter ratio (2.577) is ≤ 5 .

Note: Dynamic wind analysis is not required.

Design Wind Speed [Vz]:

= Basic Wind Speed * k1 * k2,1 * k3 * k4 (for the 1st element)
 = 47.0 * 1.0 * 1.0 * 1.0 * 1.0
 = 46.997 meters/s

Design Wind Pressure per 4.5.2 [pd]:

= $\max(0.7 * p_z, K_d * K_a * K_c * 0.6 * V_z^2)$
 = $\max(0.7 * 1325.235, 1.0 * 0.95 * 1.0 * 0.6 * 47.0^2)$
 = 1253.5 N/m²

Element Wind Load (operating condition):

= Wind Area * Cf * pd
 = 0.1 * 0.719 * 1253.528
 = 59.1 N

From	Height m	k1	k2	k3	Vz m/sec	Cf
10	0.37	1.0000	1.0000	1.0000	47.00	0.7192
20	1.15	1.0000	1.0000	1.0000	47.00	0.7192
30	2.59	1.0000	1.0000	1.0000	47.00	0.7192
40	4.59	1.0000	1.0000	1.0000	47.00	0.7192
50	5.90	1.0000	1.0000	1.0000	47.00	0.7192

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Wind Load Calculation: Step: 9 3:11pm Jul 28,2023

Wind Vibration Calculations

This evaluation is based on work by Kanti Mahajan and Ed Zorilla

Nomenclature

Cf - Correction factor for natural frequency
 D - Average outer insulated diameter of vessel, cm
 Df - Damping Factor < 0.75 Unstable, > 0.95 Stable
 Dr - Average outer insulated of top half of vessel, cm
 f - Natural frequency of vibration (Hertz)
 f1 - Natural frequency of bare vessel based on a unit value of (D/L^2) (10^4)
 L - Total height of structure cm
 Lc - Total length of conical section(s) of vessel, cm
 tb - Uncorroded plate thickness at bottom of vessel, mm
 V30 - Design Wind Speed provided by user, km/hr
 Vc - Critical wind velocity, km/hr
 Vw - Maximum wind speed at top of structure, km/hr
 W - Total corroded weight of structure, kgf
 Ws - Cor. vessel weight excl. weight of parts which do not effect stiff. kgf
 Z - Maximum amplitude of vibration at top of vessel, mm
 D1 - Logarithmic decrement (taken as 0.03 for Welded Structures)
 Vp - Vib. Chance, <= 0.00032 (High); 0.00032 < 0.0004 (Probable)
 P30 - wind pressure 30 feet above the base

Check other Conditions and Basic Assumptions:

:: Total Cone Length / Total Length < 0.5

:: 101.02/533.635 = 0.189

:: $[D / L^2] * 10^4 < 8$ (English Units, ft.):: $[7.67/17.51^2] * 10^4 = 250.091$ [Geometry Violation]**Compute the vibration possibility. If $V_p > 0.0004$ no chance. [Vp]:**

$$= W / (L * Dr^2)$$

$$= 23333 / (533.63 * 259.059^2)$$

$$= 0.65153E-03$$

Since V_p is > 0.0004 no further vibration analysis is required !**Platform Load Calculations**

ID	Wind Area cm ²	Elevation cm	Pressure kgf/m ²	Force kgf	Cf
PLAT:[1 OF 2]	28800.00	208.63	127.88	368.28	1.20
PLAT:[2 OF 2]	28800.00	518.63	127.88	368.28	1.20

The Natural Frequency for the Vessel (Ope...) is 9.01403 Hz.

Wind Load Calculation:

From	To	Wind Height cm	Wind Diameter cm	Wind Area cm ²	Wind Pressure kgf/m ²	Element Wind Load kgf
10	20	36.985	51.624	655.625	127.877	6.02782
20	30	115.416	185.976	21443	127.877	197.148
30	40	258.635	314.88	62976	127.877	876.089
40	50	458.635	314.88	62976	127.877	995.467
50	60	590.023	314.4	18486.7	127.877	169.967

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FileName : Decoking Drum_R0-28072023 -----

Wind Load Calculation: Step: 9 3:11pm Jul 28,2023

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FileName : Decoking Drum_R0-28072023 -----

Earthquake Load Calculation: Step: 10 3:11pm Jul 28,2023

Earthquake Load Calculation Results:**Seismic Analysis Results per IS 1893 (Part 4): 2015 + 2018 Amendment 2**

Importance Factor as Entered by User	I 1.5000
Zone Number	4
Soil Type	Soft Soil
Response reduction factor (Force factor)	R 3.0000
Time Period of Vibration (program or user)	0.1109 Seconds
Value of Sa/g from user Spectrum Data	0.5600
Percent Damping	2.0 %
Considering MCE for load determination	No

Horizontal Seismic Coefficient per 7.3.1 [Ah]:

$$\begin{aligned}
 &= (Sa / g * DampVal) / (R / I) \\
 &= (0.56 * 1.4) / 2.0 \\
 &= 0.392
 \end{aligned}$$

User Spectrum Data points specified for increments of Time Period

Time Period	Sa/g
0.010	0.160
0.050	0.392
0.100	0.560
0.130	0.560
0.200	0.560
0.270	0.560
0.300	0.560
0.400	0.560
0.500	0.560
0.550	0.560
0.600	0.516
0.670	0.460
0.800	0.385
1.000	0.308
1.200	0.257
1.400	0.220
1.600	0.193
1.800	0.171
2.000	0.154
2.400	0.128
2.800	0.110
3.000	0.103
3.500	0.088
4.000	0.077
4.500	0.068
5.000	0.062
5.500	0.056
6.000	0.051
6.500	0.047
7.000	0.044

Actual Time Period = 0.1109 secs

Computed Sa/g = 0.56

Note:

It was indicated to apply the damping factor, this assumes that the Site Spectrum specified is for 5% damping. If your Sa/g values are already per the actual damping value of the vessel then do not apply the damping factor.

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FileName : Decoking Drum_R0-28072023 -----

Earthquake Load Calculation: Step: 10 3:11pm Jul 28,2023

Earthquake Element Load, for the first Element:

$$\begin{aligned}
 &= \text{Earthquake Weight} * Ah * \text{Scalar} \\
 &= 56.09 * 0.392 * 1.3 \\
 &= 28.6 \text{ kgf}
 \end{aligned}$$

Vertical load per 7.4:

$$\begin{aligned}
 &= 2/3 * Ah * W * \text{Scalar} \\
 &= 2/3 * 0.392 * 23540 * 1.3 \\
 &= 7997.2 \text{ kgf}
 \end{aligned}$$

The Natural Frequency for the Vessel (Ope...) is 9.01403 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height cm	Earthquake Weight kgf	Element Ope Load kgf	Element Emp Load kgf	Element Vertical Load kgf
10	20	6.985	56.0896	28.5833	25.804	-19.0555
20	30	70.985	5024.85	2560.66	309.9	-1726.16
30	Legs	160.635	2065.92	1052.79	183.418	-2428.03
Legs	40	244.635	10846.1	5527.16	962.947	5569.16
40	50	428.635	4462.72	2274.2	769.389	1884.39
50	60	531.135	1083.95	552.379	474.31	368.253

Note:

The Earthquake Loads calculated and printed in the Earthquake Load calculation report have been factored by the input scalar/load reduction factor of: 1.300.

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FileName : Decoking Drum_R0-28072023 -----

Wind/Earthquake Shear, Bending: Step: 11 3:11pm Jul 28,2023

The following table is for the Operating Case.

Wind/ Earthquake Shear, Bending:

From	To	Distance to Support cm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgf-m.	Earthquake Bending kgf-m.
10	20	153.65	...	...	...	...
20	30	89.65	6.02782	28.5833	0.38277	1.81504
30	Legs	16	203.175	2589.25	120.989	1511
Legs	40	84	2104.52	10943	3756.42	10435.8
40	50	268	1165.43	2826.58	1388.75	3552.34
50	60	399.388	169.967	552.379	53.3484	173.378

Note:

The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 1.300.

Note:

Review the Vessel Design Summary for the cumulative shear force and bending moment on the support.

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FileName : Decoking Drum_R0-28072023 -----

Wind/Earthquake Deflection: Step: 12 3:11pm Jul 28,2023

Wind and Earthquake Deflection Calculations:

The following table is for Earthquake Deflection; Operating Case.

Earthquake Load Deflection:

From	To	Cumulative Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	...	47.2098	47.2098	0.019398
20	30	...	47.2098	47.2098	0.019398
30	Legs	2589.25	47.2099	47.2103	0.019401
Legs	40	10943	47.2168	47.2281	0.019413
40	50	2826.58	47.2444	47.262	0.019416
50	60	552.379	47.2624	47.2628	0.019416

Allowable deflection at the Tower Top (Ope) (6.000"/100ft. Criteria)

*Allowable deflection : 26.682 Actual deflection : 47.263 mm***** Warning: Allowable Deflection Criteria Exceeded ****

The following table is for Wind Deflection; Operating Case.

Wind Load Deflection:

From	To	Cumulative Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	...	9.07914	9.07914	0.00373
20	30	...	9.07914	9.07914	0.00373
30	Legs	203.175	9.07919	9.07935	0.0037312
Legs	40	2104.52	9.08163	9.0857	0.0037356
40	50	1165.43	9.09178	9.09836	0.0037366
50	60	169.967	9.09853	9.09869	0.0037366

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed km/hr	2nd Crit. Wind Speed km/hr
10	20	83.5356	522.097
20	30	300.938	1880.86
30	40	509.524	3184.53
40	50	509.524	3184.53
50	60	508.748	3179.67

Allowable deflection at the Tower Top (Ope) (6.000"/100ft. Criteria)

Allowable deflection : 26.682 Actual deflection : 9.099 mm

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FileName : Decoking Drum_R0-28072023 -----

Longitudinal Stress Constants: Step: 13 3:11pm Jul 28,2023

Longitudinal Stress Constants:

From	To	Metal Area New cm ²	Metal Area Corroded cm ²	Section Modulus New mm ³	Section Modulus Corroded mm ³
10	20	126.688	92.8905	1128284	840518
20	30	138.582	104.785	1234621	948371
30	40	947.004	711.103	59190564	44551748
40	50	947.004	711.103	59190564	44551748
50	60	788.539	552.638	49285176	34623124

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FileName : Decoking Drum_R0-28072023 -----

Longitudinal Allowable Stresses: Step: 14 3:11pm Jul 28,2023

Longitudinal Allowable Stresses:

From	To	Tensile kgf/cm ²	Hydrotest Tensile kgf/cm ²	Compressive kgf/cm ²	Hydrotest Compressive kgf/cm ²
10	20	1489.66	2193.58	-977.065	-1501.76
20	30	1572.01	2193.58	-994.739	-1501.76
30	Legs	1572.01	2193.58	-688.615	-1106.57
Legs	40	1572.01	2193.58	-688.615	-1106.57
40	50	1572.01	2193.58	-688.615	-1106.57
50	60	1572.01	2193.58	-646.917	-1040.74

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FileName : Decoking Drum_R0-28072023 -----

Longitudinal Stresses due to: Step: 15 3:11pm Jul 28,2023

Longitudinal Stress Report

Longitudinal Operating and Empty Stresses are computed in the corroded condition. Stresses due to loads in the hydrostatic test cases have been computed in the new and cold condition.

Longitudinal Pressure Stresses due to:

From	To	Longitudinal Stress Internal Pressure kgf/cm ²	Longitudinal Stress External Pressure kgf/cm ²	Longitudinal Stress Hydrotest Pressure kgf/cm ²
10	20	...	...	...
20	30	39.7859	-13.1524	116.51
30	40	242.939	-74.2038	726.249
40	50	242.939	-74.2038	726.249
50	60	312.55	-95.1788	872.059

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty kgf/cm ²	Wght. Str. Operating kgf/cm ²	Wght. Str. Hydrotest kgf/cm ²	Wght. Str. Emp. Mom. kgf/cm ²	Wght. Str. Opr. Mom. kgf/cm ²
10	20	...	...	...	...	...
20	30	0.53529	0.53529	...	1.35255	1.35255
30	Legs	1.0912	7.14516	...	1.31538	1.31538
Legs	40	-13.7791	-12.0127	...	0.043432	0.043432
40	50	-7.8001	-7.8001	...	0.043432	0.043432
50	60	-1.96141	-1.96141	...	...	...

Longitudinal Stresses due to Weight Loads and Bending for these Conditions:

From	To	Wght. Str. Hyd. Mom. kgf/cm ²	Bend. Str. Oper. Wind kgf/cm ²	Bend. Str. Oper. Equ. kgf/cm ²	Bend. Str. Hyd. Wind kgf/cm ²	Bend. Str. Hyd. Equ. kgf/cm ²
10	20	...	...	...	...	...
20	30	...	0.040361	0.19138	...	...
30	Legs	...	0.27157	3.39155	...	...
Legs	40	...	8.43158	23.424	...	...
40	50	...	3.11716	7.97352	...	...
50	60	...	0.15408	0.50076	...	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case kgf/cm ²	Vortex Shedding Empty Case kgf/cm ²	Vortex Shedding Test Case kgf/cm ²	Earthquake Empty Case kgf/cm ²
10	20	...	...	...	...
20	30	...	...	...	0.17278
30	Legs	...	...	...	0.47147
Legs	40	...	...	...	9.91736

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FileName : Decoking Drum_R0-28072023 -----

Longitudinal Stresses due to: Step: 15 3:11pm Jul 28,2023

40	50	...	...	...	4.19038
50	60	...	...	...	0.42999

Longitudinal Stresses due to Applied Axial Forces:

From	To	Longitudinal Stress Y Forces Wind kgf/cm ²	Longitudinal Stress Y Forces Seismic kgf/cm ²
10	20	...	-0.20514
20	30	...	-16.4735
30	Legs	...	-3.41446
Legs	40	...	7.83174
40	50	...	2.64995
50	60	...	0.66636

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded kgf/cm ²	Earthquake For/Mom Corroded kgf/cm ²	Wind For/Mom No Corrosion kgf/cm ²	Earthquake For/Mom No Corrosion kgf/cm ²
10	20	...	...	...	...
20	30	...	...	...	...
30	Legs	...	...	...	...
Legs	40	...	...	...	...
40	50	...	...	...	...
50	60	...	...	...	...

Bending Stresses due to Blast Load:

From	To	Bending Stress kgf/cm ²
10	20	...
20	30	...
30	Legs	...
Legs	40	...
40	50	...
50	60	...

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FileName : Decoking Drum_R0-28072023 -----

Stress due to Combined Loads: Step: 16 3:11pm Jul 28,2023

Stress Combination Load Cases for Vertical Vessels:**Load Case Definition Key**

IP = Longitudinal Stress due to Internal Pressure
 EP = Longitudinal Stress due to External Pressure
 HP = Longitudinal Stress due to Hydrotest Pressure
 NP = No Pressure
 EW = Longitudinal Stress due to Weight (No Liquid)
 OW = Longitudinal Stress due to Weight (Operating)
 HW = Longitudinal Stress due to Weight (Hydrotest)
 WI = Bending Stress due to Wind Moment (Operating)
 EQ = Bending Stress due to Earthquake Moment (Operating)
 EE = Bending Stress due to Earthquake Moment (Empty)
 HI = Bending Stress due to Wind Moment (Hydrotest)
 HE = Bending Stress due to Earthquake Moment (Hydrotest)
 WE = Bending Stress due to Wind Moment (Empty) (no CA)
 WF = Bending Stress due to Wind Moment (Filled) (no CA)
 CW = Longitudinal Stress due to Weight (Empty) (no CA)
 VO = Bending Stress due to Vortex Shedding Loads (Ope)
 VE = Bending Stress due to Vortex Shedding Loads (Emp)
 VF = Bending Stress due to Vortex Shedding Loads (Test No CA.)
 FW = Axial Stress due to Vertical Forces for the Wind Case
 FS = Axial Stress due to Vertical Forces for the Seismic Case
 BW = Bending Stress due to Lat. Forces for the Wind Case, Corroded
 BS = Bending Stress due to Lat. Forces for the Seismic Case, Corroded
 BN = Bending Stress due to Lat. Forces for the Wind Case, UnCorroded
 BU = Bending Stress due to Lat. Forces for the Seismic Case, UnCorroded
 BL = Bending Stress due to Blast Loads, Corroded

General Notes:

Case types HI and HE are in the Un-Corroded condition.

Case types WE, WF, and CW are in the Un-Corroded condition.

A blank stress and stress ratio indicates that the corresponding stress comprising those components that did not contribute to that type of stress.

An asterisk (*) in the final column denotes overstress.

Analysis of Load Case 1 : NP+ EW+ WI+ FW+ BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	1.93	1572.01	-0.86	994.74	0.0012	0.0009
30	2.68	1572.01	-0.50	688.62	0.0017	0.0007
30		1572.01	-22.25	688.62		0.0323
40		1572.01	-10.96	688.62		0.0159
50		1572.01	-2.12	646.92		0.0033

Analysis of Load Case 2 : NP+ EW+ EE+ FS+ BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20		1572.01	-17.46	994.74		0.0176
30		1572.01	-4.11	688.62		0.0060
30	4.01	1572.01	-15.91	688.62	0.0026	0.0231
40		1572.01	-9.38	688.62		0.0136
50		1572.01	-1.73	646.92		0.0027

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Stress due to Combined Loads: Step: 16 3:11pm Jul 28,2023

Analysis of Load Case 3 : NP+ OW+ WI+ FW+ BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	1.93	1572.01	-0.86	994.74	0.0012	0.0009
30	8.73	1572.01		688.62	0.0056	
30		1572.01	-20.49	688.62		0.0298
40		1572.01	-10.96	688.62		0.0159
50		1572.01	-2.12	646.92		0.0033

Analysis of Load Case 4 : NP+ OW+ EQ+ FS+ BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20		1572.01	-17.48	994.74		0.0176
30	8.44	1572.01	-0.98	688.62	0.0054	0.0014
30	19.29	1572.01	-27.65	688.62	0.0123	0.0402
40	2.87	1572.01	-13.17	688.62	0.0018	0.0191
50		1572.01	-1.80	646.92		0.0028

Analysis of Load Case 5 : NP+ HW+ HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	0.00	2193.58	0.00	1501.76	0.0000	0.0000
30	0.00	2193.58	0.00	1106.57	0.0000	0.0000
30	0.00	2193.58	0.00	1106.57	0.0000	0.0000
40	0.00	2193.58	0.00	1106.57	0.0000	0.0000
50	0.00	2193.58	0.00	1040.74	0.0000	0.0000

Analysis of Load Case 6 : NP+ HW+ HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	0.00	2193.58	0.00	1501.76	0.0000	0.0000
30	0.00	2193.58	0.00	1106.57	0.0000	0.0000
30	0.00	2193.58	0.00	1106.57	0.0000	0.0000
40	0.00	2193.58	0.00	1106.57	0.0000	0.0000
50	0.00	2193.58	0.00	1040.74	0.0000	0.0000

Analysis of Load Case 7 : IP+ OW+ WI+ FW+ BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	41.71	1572.01		994.74	0.0265	
30	251.67	1572.01		688.62	0.1601	
30	239.40	1572.01		688.62	0.1523	
40	238.30	1572.01		688.62	0.1516	
50	310.74	1572.01		646.92	0.1977	

Analysis of Load Case 8 : IP+ OW+ EQ+ FS+ BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	25.39	1572.01		994.74	0.0162	
30	251.38	1572.01		688.62	0.1599	
30	262.23	1572.01		688.62	0.1668	
40	245.81	1572.01		688.62	0.1564	
50	311.76	1572.01		646.92	0.1983	

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FileName : Decoking Drum_R0-28072023 -----

Stress due to Combined Loads: Step: 16 3:11pm Jul 28,2023

Analysis of Load Case 9 : EP+ OW+ WI+ FW+ BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20		1572.01	-14.01	994.74		0.0141
30		1572.01	-68.65	688.62		0.0997
30		1572.01	-94.69	688.62		0.1375
40		1572.01	-85.16	688.62		0.1237
50		1572.01	-97.29	646.92		0.1504

Analysis of Load Case 10 : EP+ OW+ EQ+ FS+ BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20		1572.01	-30.63	994.74		0.0308
30		1572.01	-75.18	688.62		0.1092
30		1572.01	-101.85	688.62		0.1479
40		1572.01	-87.37	688.62		0.1269
50		1572.01	-96.97	646.92		0.1499

Analysis of Load Case 11 : HP+ HW+ HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	116.51	2193.58		1501.76	0.0531	
30	726.25	2193.58		1106.57	0.3311	
30	726.25	2193.58		1106.57	0.3311	
40	726.25	2193.58		1106.57	0.3311	
50	872.06	2193.58		1040.74	0.3976	

Analysis of Load Case 12 : HP+ HW+ HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	116.51	2193.58		1501.76	0.0531	
30	726.25	2193.58		1106.57	0.3311	
30	726.25	2193.58		1106.57	0.3311	
40	726.25	2193.58		1106.57	0.3311	
50	872.06	2193.58		1040.74	0.3976	

Analysis of Load Case 13 : IP+ WE+ EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	41.67	1572.01		994.74	0.0265	
30	245.35	1572.01		688.62	0.1561	
30	229.20	1572.01		688.62	0.1458	
40	235.18	1572.01		688.62	0.1496	
50	310.59	1572.01		646.92	0.1976	

Analysis of Load Case 14 : IP+ WF+ CW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	40.19	1572.01		994.74	0.0256	
30	248.30	1572.01		688.62	0.1580	
30	233.92	1572.01		688.62	0.1488	
40	237.08	1572.01		688.62	0.1508	
50	311.18	1572.01		646.92	0.1979	

Analysis of Load Case 15 : IP+ VO+ OW

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Stress due to Combined Loads: Step: 16 3:11pm Jul 28,2023

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	41.67	1572.01		994.74	0.0265	
30	251.40	1572.01		688.62	0.1599	
30	230.97	1572.01		688.62	0.1469	
40	235.18	1572.01		688.62	0.1496	
50	310.59	1572.01		646.92	0.1976	

Analysis of Load Case 16 : IP+ VE+ EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	41.67	1572.01		994.74	0.0265	
30	245.35	1572.01		688.62	0.1561	
30	229.20	1572.01		688.62	0.1458	
40	235.18	1572.01		688.62	0.1496	
50	310.59	1572.01		646.92	0.1976	

Analysis of Load Case 17 : NP+ VO+ OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	1.89	1572.01	-0.82	994.74	0.0012	0.0008
30	8.46	1572.01		688.62	0.0054	
30		1572.01	-12.06	688.62		0.0175
40		1572.01	-7.84	688.62		0.0114
50		1572.01	-1.96	646.92		0.0030

Analysis of Load Case 18 : FS+ BS+ IP+ OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	25.20	1572.01		994.74	0.0160	
30	247.98	1572.01		688.62	0.1577	
30	238.80	1572.01		688.62	0.1519	
40	237.83	1572.01		688.62	0.1513	
50	311.25	1572.01		646.92	0.1980	

Analysis of Load Case 19 : FS+ BS+ EP+ OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20		1572.01	-30.44	994.74		0.0306
30		1572.01	-71.79	688.62		0.1043
30		1572.01	-78.43	688.62		0.1139
40		1572.01	-79.40	688.62		0.1153
50		1572.01	-96.47	646.92		0.1491

Analysis of Load Case 20 : BL+ IP+ OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
20	41.67	1572.01		994.74	0.0265	
30	251.40	1572.01		688.62	0.1599	
30	230.97	1572.01		688.62	0.1469	
40	235.18	1572.01		688.62	0.1496	
50	310.59	1572.01		646.92	0.1976	

Absolute Maximum of the all of the Stress Ratio's

0.3976

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FileName : Decoking Drum_R0-28072023 -----

Stress due to Combined Loads: Step: 16 3:11pm Jul 28,2023

Governing Element: Top DEnd

Governing Load Case 11 : HP+HW+HI

Element Description	Long Pressure Stress	Weight + Axial Load Stress	Eccentric Moment Stress	Wind or Earthquake Stress	Combined Stress	Which Side	
ToriCone	116.5	...	...	...	116.5	+	Tens
ToriCone	116.5	...	...	...	...	-	Comp
Shell-Sec-2	726.2	...	...	...	726.2	+	Tens
Shell-Sec-2	726.2	...	...	...	...	-	Comp
Shell-Sec-2	726.2	...	...	...	726.2	+	Tens
Shell-Sec-2	726.2	...	...	...	...	-	Comp
Shell-Sec-1	726.2	...	...	...	726.2	+	Tens
Shell-Sec-1	726.2	...	...	...	...	-	Comp
Top DEnd	872.1	...	...	...	872.1	+	Tens
Top DEnd	872.1	...	...	...	...	-	Comp

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FileName : Decoking Drum_R0-28072023 -----

Center of Gravity Calculation: Step: 17 3:11pm Jul 28,2023

Shop/ Field Installation Options :

Platform(s) installed in the Field before being lifted.
 Insulation is installed in the Field before being lifted.

Note : The CG is computed from the first Element From Node

Center of Gravity of the Platforms	339.131 cm
Center of Gravity of the Liquid	140.510 cm
Center of Gravity of the Insulation	333.857 cm
Center of Gravity of the Stiffening Rings	304.635 cm
Center of Gravity of the Nozzles	337.127 cm
Center of Gravity of the Legs	-21.865 cm
Center of Gravity of Bare Shell New and Cold	329.710 cm
Center of Gravity of Bare Shell Corroded	325.948 cm
Vessel CG in the Operating Condition	220.354 cm
Vessel CG in the Fabricated (Shop/Empty) Condition	285.008 cm
Vessel CG in the Test Condition	315.764 cm

Warning: Lifting Lug is Higher than top of vessel!**Rigging Analysis Results:**

Total Effective Length of Vessel for this analysis	533.00 cm
Total vessel weight (No Liquid) Twt	5667.45 kgf
Impact weight multiplication factor Imp	2.00
Design lifting weight, DWT = Imp * Twt	11334.90 kgf
Elevation of the Tailing Lug (bottom)	0.00 cm
Elevation of the Lifting Lug (top)	593.02 cm
Design Reaction force at the tailing lug	5887.27 kgf
Design Reaction force at the lifting lug	5447.63 kgf
CG Distance from Tailing Lug	285.01 cm
CG Distance from the Nearer Lifting Lug/Trunnion	285.01 cm
Compressive Allowable Increase Factor	1.00

Critical Values:

	Max Stress kgf/cm ²	Elevation cm	Allowables kgf/cm ²	
Bending	58.55	10.16	1251.46	(UG-23)
Shear	47.67	0.00	984.30	(0.7*S)

The compressive bending allowable stress is the minimum of the tensile allowable and the compressive allowable times the specified compressive allowable increase factor.

Forces and Moments at selected elevations (not all analysis points shown):

Distance cm	Bending Moment kgf-m.	Bending Stress kgf/cm ²	Shear Force kgf	Shear Stress kgf/cm ²
0.00	0.0	0.0	5621.2	47.7
10.16	571.1	58.6	4109.9	34.9
81.88	3577.2	11.1	2935.5	3.8
208.00	6519.2	11.0	331.6	0.4
368.00	5916.3	10.0	2313.2	2.4

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FileName : Decoking Drum_R0-28072023 -----

Center of Gravity Calculation: Step: 17 3:11pm Jul 28,2023

528.00

2215.1

4.5

3824.6

4.9

Unity Check (Actual Stress / Allowable Stress):

Maximum Unity Check is 0.0468 at elevation 10.16 cm - Must be <=1

Note: The rigging analysis is performed using a uniformly distributed load.

--- Plot data successfully generated ...----

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FileName : Decoking Drum_R0-28072023 -----

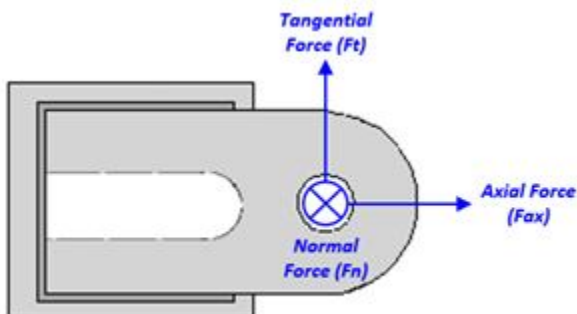
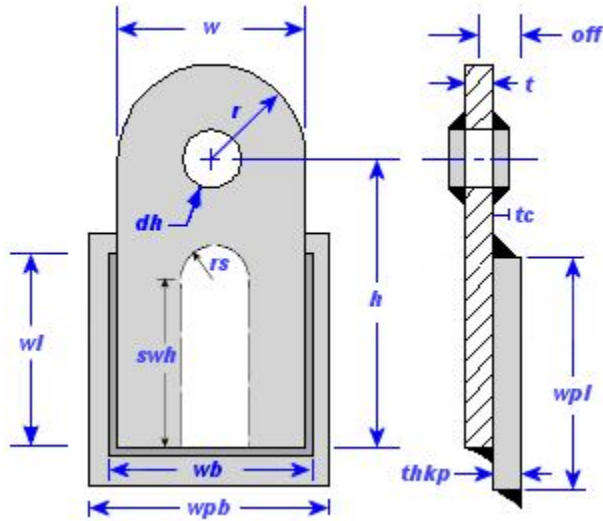
Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Lifting Lug Calculations:**Input Values:**

Lifting Lug Material	SA-516 70
Lifting Lug Yield Stress	Yield 2671.70 kgf/cm ²
Width of Lifting Lug	w 260.0000 mm
Thickness of Lifting Lug	t 20.0000 mm
Diameter of Hole in Lifting Lug	dh 62.0000 mm
Radius of Semi-Circular Arc of Lifting Lug	r 130.0000 mm
Height of Lug from bottom to Center of Hole	h 726.0000 mm
Offset from Vessel OD to Center of Hole	off 10.0000 mm
Lug Fillet Weld Size	tw 14.0000 mm
Length of weld along side of Lifting Lug	wl 200.0000 mm
Length of Weld along Bottom of Lifting Lug	wb 260.0000 mm
Thickness of Collar (if any)	tc 0.0000 mm
Diameter of Collar (if any)	dc 0.0000 mm
Impact Factor	Impfac 2.00
Number of Lugs in Group	2

Lifting Lug Orientation to Vessel: Flat

Lift Orientation : From Horizontal to Vertical



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Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

PV Elite computes the forces and stresses from 0 to 90 degrees at 1 degree increments. The table below provides the results in 5 degree increments.

The 0 degree angle position is in the horizontal direction and the 90 degree angle position is in the vertical direction.

PV Elite does not compute weak axis bending forces on the lugs. It is assumed that a spreader bar is used.

Lifting Lug and Weld Stresses at various Angles: kgf/cm²

Angle	----- Weld Stresses			----- Lug Stresses		Maximum Ratio
	Primary	Secondary	Allowable	Combined	Allowable	
0	46.3	345.1	1068.7	635.8	1763.3	0.361
5	47.6	345.3	1068.7	640.7	1763.3	0.363
10	48.9	342.8	1068.7	640.7	1763.3	0.363
15	50.1	337.7	1068.7	635.8	1763.3	0.361
20	51.3	330.0	1068.7	626.1	1763.3	0.355
25	52.4	319.7	1068.7	611.7	1763.3	0.347
30	53.5	307.1	1068.7	592.6	1763.3	0.336
35	54.5	292.1	1068.7	569.1	1763.3	0.323
40	55.5	274.8	1068.7	541.2	1763.3	0.307
45	56.4	255.4	1068.7	509.3	1763.3	0.289
50	57.4	234.0	1068.7	473.5	1763.3	0.269
55	58.3	210.9	1068.7	434.2	1763.3	0.246
60	59.3	186.0	1068.7	391.6	1763.3	0.222
65	60.4	159.7	1068.7	346.2	1763.3	0.196
70	61.7	132.1	1068.7	298.4	1763.3	0.169
75	63.7	103.2	1068.7	248.6	1763.3	0.141
80	67.0	73.1	1068.7	197.6	1763.3	0.112
85	74.8	41.1	1068.7	147.1	1763.3	0.083
90	113.1	10.7	1068.7	109.0	1763.3	0.106

Computed Results:

Total vessel weight (No Liquid)	5667.45 kgf
Design Reaction force at the tailing lug	5887.27 kgf
Design Reaction force at the lifting lug	5447.63 kgf

Worst Case Lift Angle for Primary Weld Stresses	90 deg
Tangential Force at this Angle	0.0 kgf
Axial Force at this Angle	5667.4 kgf

Worst Case Lift Angle for Secondary Weld Stresses	3 deg
Tangential Force at this Angle	2727.0 kgf
Axial Force at this Angle	142.9 kgf

Worst Case Lift Angle for Lug Stresses	7 deg
Tangential Force at this Angle	2719.6 kgf
Axial Force at this Angle	333.9 kgf

Converting the weld leg dimension (tw) to the weld throat dimension.

Weld Group Inertia Calculations:

Weld Group Inertia about the Circumferential Axis	I _{lc}	3039.717 cm**4
Weld Group Centroid distance in the Long. Direction	Y _{ll}	141.344 mm
Dist. of Weld Group Centroid from Lug bottom	Y _{ll_b}	58.656 mm
Weld Group Inertia about the Longitudinal Axis	I _{ll}	7644.259 cm**4

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Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Weld Group Centroid Distance in the Circ. Direction Ylc 130.000 mm

Note: The Impact Factor is applied to the Forces acting on the Lug.

Primary Shear Stress in the Welds due to Shear Loads [Ssl]:

$$\begin{aligned}
 &= \sqrt{(F_{ax}^2 + F_t^2 + F_n^2) / ((2 * w_l + w_b) * t_w)} \\
 &= \sqrt{(5667^2 + 0^2 + 0^2) / ((2 * 200.0 + 260.0) * 9.898)} \\
 &= 86.76 \text{ kgf/cm}^2
 \end{aligned}$$

Shear Stress in the Welds due to Bending Loads [Sblf]:

$$\begin{aligned}
 &= (F_n(h - Y_{ll_b}))Y_{ll}/I_{lc} + (F_{ax} * off * Y_{ll}/I_{lc}) + (F_t * off * Y_{lc}/I_{ll}) \\
 &= (0(726.0 - 58.656))141.344/3039.717 + \\
 &\quad (5667 * 10.0 * 141.344/3039.717) + \\
 &\quad (0 * 10.0 * 130.0/7644.259) \\
 &= 26.35 \text{ kgf/cm}^2
 \end{aligned}$$

Total Shear Stress for Combined Loads [St]:

$$\begin{aligned}
 &= S_{sl} + S_{blf} \\
 &= 86.755 + 26.353 \\
 &= 113.11 \text{ kgf/cm}^2
 \end{aligned}$$

Allowable Shear Stress for Combined Loads [Sta]:

$$\begin{aligned}
 &= 0.4 * Yield * Occfac \text{ (AISC Shear Allowable)} \\
 &= 0.4 * 2672 * 1.0 \\
 &= 1068.68 \text{ kgf/cm}^2
 \end{aligned}$$

Secondary Shear Stress in the Welds due to Shear Loads:

Unit Weld Polar Section Modulus [Uwsm]:

$$\begin{aligned}
 &= (2 * w_l + w)^3 / 12 - w_l^2 (w_l + w)^2 / (2 * w_l + w) \\
 &= 11133759.00 \text{ mm}^3
 \end{aligned}$$

Loads on Welds due to Torsional Moment:

Shear Stress in Normal Direction [Fth]:

$$\begin{aligned}
 &= F_t * (h - (w_l - Cent)) * (w_b / 2) / U_{wsm} \\
 &= 21.19 \text{ kgf/mm}
 \end{aligned}$$

Shear Stress in Circumferential Direction [Ftv]:

$$\begin{aligned}
 &= F_t * (h - (w_l - Cent)) * Cent / U_{wsm} \\
 &= 22.72 \text{ kgf/mm}
 \end{aligned}$$

Primary Shear Stress [Fsv]:

$$\begin{aligned}
 &= F_t / (2 * w_l + w) \\
 &= 4.13 \text{ kgf/mm}
 \end{aligned}$$

Resultant Load on Weld Group [Fr]:

$$\begin{aligned}
 &= \sqrt{F_{th}^2 + (F_{tv} + F_{sv})^2} \\
 &= \sqrt{21.2^2 + (22.7 + 4.1)^2} \\
 &= 34.20 \text{ kgf/mm}
 \end{aligned}$$

Resultant Secondary Weld Stress [Fws]:

$$\begin{aligned}
 &= Fr / T_{weld} \\
 &= 34.202 / 9.898 \\
 &= 345.54 \text{ kgf/cm}^2
 \end{aligned}$$

Allowable Resultant Secondary Weld Stress [Psa]:

$$\begin{aligned}
 &= 0.4 * Yield * Occfac \\
 &= 0.4 * 2671.7 * 1.0 \\
 &= 1068.68 \text{ kgf/cm}^2
 \end{aligned}$$

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FileName : Decoking Drum_R0-28072023 -----

Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Shear Stress in Lug above Hole [Shs]:

$$\begin{aligned}
 &= \sqrt{P1^2 + Fn^2} / Sha \\
 &= \sqrt{5667^2 + 0^2} / 39.6 \\
 &= 143.12 \text{ kgf/cm}^2
 \end{aligned}$$

Allowable Shear Stress in Lug above Hole [Sas]:

$$\begin{aligned}
 &= 0.4 * Yield * Occfac \\
 &= 0.4 * 2672 * 1.0 \\
 &= 1068.68 \text{ kgf/cm}^2
 \end{aligned}$$

Pin Hole Bearing Width [Pbw]:

$$\begin{aligned}
 &= Lug \text{ Thickness} + 2 * Collar \text{ Thickness} \\
 &= 20.0 + 2 * 0.0 \\
 &= 20.000 \text{ mm}
 \end{aligned}$$

Pin Hole Bearing Stress [Pbs]:

$$\begin{aligned}
 &= \sqrt{P1^2 + Fn^2} / (Pbw * dh) \\
 &= \sqrt{5667^2 + 0^2} / (20.0 * 62.0) \\
 &= 457.05 \text{ kgf/cm}^2
 \end{aligned}$$

Allowable Bearing Stress [Pba]:

$$\begin{aligned}
 &= \min(0.75 * Yield * Occfac, 0.9 * Yield) \text{ AISC Bearing All.} \\
 &= \min(0.75 * 2672 * 1.0, 2404.5) \\
 &= 2003.77 \text{ kgf/cm}^2
 \end{aligned}$$

Bending Stress at the Base of the Lug [Fbs]:

$$\begin{aligned}
 &= Fn * (h - w1) / (w * t^2 / 6) + Ft * (h - w1) / (w^2 * t / 6) \\
 &= 0 * (726.0 - 200.0) / (260.0 * 20.0^2 / 6) + \\
 &\quad 2720 * (726.0 - 200.0) / (260.0^2 * 20.0 / 6) \\
 &= 634.83 \text{ kgf/cm}^2
 \end{aligned}$$

Tensile Stress at the Base of the Lug [Fa]:

$$\begin{aligned}
 &= Fax / (w * t) \\
 &= 334 / (260.0 * 20.0) \\
 &= 6.42 \text{ kgf/cm}^2
 \end{aligned}$$

Total Combined Stress at the Base of the Lug:

$$\begin{aligned}
 &= Fbs + Fa \\
 &= 634.8 + 6.4 \\
 &= 641.25 \text{ kgf/cm}^2
 \end{aligned}$$

Lug Allowable Stress for Bending and Tension:

$$\begin{aligned}
 &= \min(0.66 * Yield * Occfac, 0.75 * Yield) \\
 &= \min(0.66 * 2672 * 1.0, 2003.8) \\
 &= 1763.32 \text{ kgf/cm}^2
 \end{aligned}$$

Required Shackle Pin Diameter [Spd]:

$$\begin{aligned}
 &= \sqrt{(2(P1^2 + Fn^2)^{0.5} / (\pi * Sta))} \\
 &= \sqrt{(2(5667^2 + 0^2)^{0.5} / (\pi * 1069))} \\
 &= 18.3743 \text{ mm}
 \end{aligned}$$

WRC 107/537 Stress Analysis for the Lifting Lug to Shell Junction in the new and Cold Condition (no corrosion applied).

Note: The full lug load is applied in both the circumferential and longitudinal directions simultaneously.

Note: Attachment dimensions (C11P, C22P etc.) may be modified accounting for attachment welds where applicable.

Input Echo, WRC107/ 537 Item 1, Description: Lift Lug

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FileName : Decoking Drum_R0-28072023 -----

Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	0.0000	mm
Vessel Diameter	Dv	2500.000	mm
Vessel Thickness	Tv	12.000	mm

Note: Lifting lug calculations are performed at ambient temperature conditions.

Attachment Type	Type	Rectangular	
Parameter C11	C11	288.00	mm
Parameter C22	C22	214.00	mm
Thickness of Reinforcing Pad	Tpad	20.000	mm
Pad Parameter C11P	C11p	348.000	mm
Pad Parameter C22P	C22p	244.000	mm
Design Internal Pressure	Dp	0.000	kgf/cm ²
Include Pressure Thrust		No	

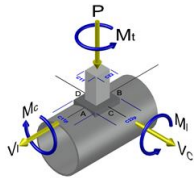
External Forces and Moments in WRC 107/537 Convention:

Radial Load	(SUS)	P	0.0	kgf
Longitudinal Shear	(SUS)	Vl	5667.4	kgf
Circumferential Shear	(SUS)	Vc	5667.4	kgf
Circumferential Moment	(SUS)	Mc	0.0	kgf-m.
Longitudinal Moment	(SUS)	Ml	0.0	kgf-m.
Torsional Moment	(SUS)	Mt	3547.8	kgf-m.

Use Interactive Control	No
WRC107 Version	Version March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No
Local Loads applied at end of Nozzle/Attachment	No

WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



WRC 107/537 has dimensional limitations that can be found in the bulletin's Foreword and which can also be inferred by review of the non-dimensional curve limits.

WRC 107 Stress Calculation for SUS tained loads:

Radial Load	P	0.0	kgf
Circumferential Shear	VC	5667.4	kgf
Longitudinal Shear	VL	5667.4	kgf
Circumferential Moment	MC	0.0	kgf-m.
Longitudinal Moment	ML	0.0	kgf-m.
Torsional Moment	MT	3547.8	kgf-m.

Dimensionless Parameters used : Gamma = 39.56

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FileName : Decoking Drum_R0-28072023 -----

Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.097	4C	6.935	(A,B)
N(PHI) / (P/Rm)	0.097	3C	6.115	(C,D)
M(PHI) / (P)	0.107	2C1	0.083	(A,B)
M(PHI) / (P)	0.107	1C	0.116	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.103	3A	1.223	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.117	1A	0.092	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.093	3B	3.853	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.098	1B	0.046	(A,B,C,D)
N(x) / (P/Rm)	0.106	3C	5.874	(A,B)
N(x) / (P/Rm)	0.106	4C	6.847	(C,D)
M(x) / (P)	0.100	1C1	0.128	(A,B)
M(x) / (P)	0.100	2C	0.089	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.103	4A	1.777	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.115	2A	0.050	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.093	4B	1.079	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.097	2B	0.074	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (kgf/ cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VC		30.7	30.7	-30.7	-30.7	0.0	0.0	0.0	0.0
Shear VL		0.0	0.0	0.0	0.0	-41.4	-41.4	41.4	41.4
Shear MT		719.6	719.6	719.6	719.6	719.6	719.6	719.6	719.6
Tot. Shear		750.3	750.3	688.8	688.8	678.2	678.2	760.9	760.9
Str. Int.		1500.6	1500.6	1377.6	1377.6	1356.4	1356.4	1521.9	1521.9

Dimensionless Parameters used : Gamma = 104.67

Dimensionless Loads for Cylindrical Shells at Pad Edge:

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.115	4C	15.178	(A, B)
N(PHI) / (P/Rm)	0.115	3C	10.619	(C, D)
M(PHI) / (P)	0.129	2C1	0.036	(A, B)
M(PHI) / (P)	0.129	1C !	0.067	(C, D)
N(PHI) / (MC/(Rm**2 * Beta))	0.123	3A	4.116	(A, B, C, D)
M(PHI) / (MC/(Rm * Beta))	0.132	1A	0.072	(A, B, C, D)
N(PHI) / (ML/(Rm**2 * Beta))	0.109	3B	11.515	(A, B, C, D)
M(PHI) / (ML/(Rm * Beta))	0.114	1B	0.027	(A, B, C, D)
N(x) / (P/Rm)	0.127	3C	9.498	(A, B)
N(x) / (P/Rm)	0.127	4C	14.582	(C, D)
M(x) / (P)	0.119	1C1	0.074	(A, B)
M(x) / (P)	0.119	2C !	0.041	(C, D)
N(x) / (MC/(Rm**2 * Beta))	0.123	4A	7.831	(A, B, C, D)
M(x) / (MC/(Rm * Beta))	0.131	2A	0.034	(A, B, C, D)
N(x) / (ML/(Rm**2 * Beta))	0.109	4B	4.108	(A, B, C, D)
M(x) / (ML/(Rm * Beta))	0.112	2B	0.039	(A, B, C, D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (kgf/ cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Long. Str.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VC		67.9	67.9	-67.9	-67.9	0.0	0.0	0.0	0.0
Shear VL		0.0	0.0	0.0	0.0	-96.8	-96.8	96.8	96.8
Shear MT		1392.7	1392.7	1392.7	1392.7	1392.7	1392.7	1392.7	1392.7
Tot. Shear		1460.6	1460.6	1324.9	1324.9	1296.0	1296.0	1489.5	1489.5
Str. Int.		2921.2	2921.2	2649.8	2649.8	2591.9	2591.9	2979.1	2979.1

WRC 107/ 537 Stress Summations:

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Vessel Stress Summation at Attachment Junction (kgf/cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pl (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pl (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		30.7	30.7	-30.7	-30.7	-41.4	-41.4	41.4	41.4
Shear Q (SUS)		719.6	719.6	719.6	719.6	719.6	719.6	719.6	719.6
Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm+Pl (SUS)		61.5	61.5	61.5	61.5	82.8	82.8	82.8	82.8
Pm+Pl+Q (Total)		1500.6	1500.6	1377.6	1377.6	1356.4	1356.4	1521.9	1521.9

Vessel Stress Summation Comparison (kgf/cm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	1406.14	Passed
Pm+Pl (SUS)	82.76	2109.21	Passed
Pm+Pl+Q (TOTAL)	1521.88	4218.42	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.

WRC 107/ 537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (kgf/cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pl (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pl (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		67.9	67.9	-67.9	-67.9	-96.8	-96.8	96.8	96.8
Shear Q (SUS)		1392.7	1392.7	1392.7	1392.7	1392.7	1392.7	1392.7	1392.7
Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm+Pl (SUS)		135.7	135.7	135.7	135.7	193.6	193.6	193.6	193.6

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Lifting Lug Calcs: Lifting Lug Step: 18 3:11pm Jul 28,2023

Pm+Pl+Q (Total)	2921.2	2921.2	2649.8	2649.8	2591.9	2591.9	2979.1	2979.1
-----------------	--------	--------	--------	--------	--------	--------	--------	--------

Vessel Stress Summation Comparison (kgf/cm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	1406.14	Passed
Pm+Pl (SUS)	193.56	2109.21	Passed
Pm+Pl+Q (TOTAL)	2979.05	4218.42	Passed

Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Leg Check, (Operating Case): Step: 19 3:11pm Jul 28,2023

RESULTS FOR LEGS : Operating Case Description: LEGS**Legs attached to: Shell-Sec-2****Section Properties : I Beam ISMB300****India ISI Structural Steel Data**

Overall Leg Length		365.000	cm
Effective Leg Length	Leglen	333.000	cm
Distance Leg Up Side of Vessel		32.000	cm
Number of Legs	Nleg	4	
Cross Sectional Area for ISMB300	Aleg	56.260	cm ²
Section Inertia (strong axis)		8603.565	cm ⁴
Section Inertia (weak axis)		453.898	cm ⁴
Section Modulus (strong axis)		573602.312	mm ³
Section Modulus (weak axis)		64800.266	mm ³
Radius of Gyration (strong axis)		123.700	mm
Radius of Gyration (weak axis)		28.400	mm

Leg Orientation - Weak Axis

Overturning Moment at top of Legs		10435.8	kgf-m.
Total Weight Load at top of Legs	W	31536.8	kgf
Total Shear force at top of Legs		11995.8	kgf
Additional force in Leg due to Bracing	Fadd	15034.0	kgf
Occasional Load Factor	Occfac	1.333	
Effective Leg End Condition Factor	k	1.000	

Note: The Legs Are Cross Braced**The Leg Shear Force includes Wind, Seismic and Blast Load Effects.**

Pad Width along Circumference	C11P	400.000	mm
Pad Length along Vessel Axis	C22P	320.000	mm
Pad Thickness	Tpad	12.000	mm

Maximum Shear at top of one Leg [Vleg]:

$$\begin{aligned}
 &= (\max(\text{Wind, Seismic, Blast}) + \text{applied forces}) (I_{\max} / I_{\text{tot}}) \\
 &= (11995.8) (8608.7 / 18124.89) \\
 &= 5697.57 \text{ kgf}
 \end{aligned}$$

Axial Compression, Leg furthest from the Neutral Axis [Sma]:

$$\begin{aligned}
 &= W / N_{\text{leg}} + (M_{\text{leg}} / (N_{\text{leg}} * R_n)) / A_{\text{leg}} \\
 &= 309271 / 4 + (.10234 \text{E}+09 / (2 * 1320.034)) / 5625.988 \\
 &= 210.40 \text{ kgf/cm}^2
 \end{aligned}$$

Axial Compression, Leg closest to the Neutral Axis [Sva]:

$$\begin{aligned}
 &= (W / N_{\text{leg}} + F_{\text{add}}) / A_{\text{leg}} \\
 &= (31537 / 4 + 15034.0) / 56.26 \\
 &= 407.36 \text{ kgf/cm}^2
 \end{aligned}$$

Allowable Compressive Stress for the Selected Leg (KL/r < Cc) [Sa]:

$$\begin{aligned}
 &= \text{Occfac} (1 - (kL/r)^2 / (2 * C_c^2)) F_y / (5/3 + 3 (Kl/r) / (8 * C_c) - (Kl/r^3) / (8 * C_c^3)) \\
 &= 1.33 (1 - (117.25)^2 / (2 * 127.18^2)) 2531 / (5/3 + 3 (117.25) / (8 * 127.18) - (117.25^3) / (8 * 127.18^3)) \\
 &= 1013.37 \text{ kgf/cm}^2
 \end{aligned}$$

Bending at the Bottom of the Leg closest to the N.A. [S]:

$$= (V_{\text{leg}} * \text{Leglen} / S_{\text{mdwa}})$$

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Leg Check, (Operating Case): Step: 19 3:11pm Jul 28,2023

= (5697.57 * 333.0/64800.27)
 = 0 since the legs are Cross Braced

Allowable Bending Stress[Sb]:

= (0.6 * Fy * Occfac)
 = (0.6 * 2531 * 1.33)
 = 2024.33 kgf/cm²

AISC Unity Check [Sc](must be <= to 1 and > 0) :

= (Sva/Sa)+(0.85*S)/((1-Sva/Spex)*Sb)
 = (407/1013)+(0.85 *0.0)/((1 -407/1036) *2024)
 = 0.4020

WRC 107 Stress Analysis for Leg to Shell Junction, Ope Condition

Rectangular Attachment Parameter	C11	299.999	mm
Rectangular Attachment Parameter	C22	300.950	mm

Input Echo, WRC107/ 537 Item 1, Description: LEGS

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm
Vessel Diameter	Dv	2500.000	mm
Vessel Thickness	Tv	12.000	mm
Design Temperature	T1	350.0	C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	1406.14	kgf/cm ²
Vessel Hot S.I. Allowable	Smh	1310.01	kgf/cm ²

Using 2 * Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.
 Make sure that material properties at this temperature are not
 time-dependent for Material: SA-516 70

Attachment Type	Type	Rectangular	
Parameter C11	C11	300.00	mm
Parameter C22	C22	300.95	mm
Thickness of Reinforcing Pad	Tpad	12.000	mm
Pad Parameter C11P	C11p	400.000	mm
Pad Parameter C22P	C22p	320.000	mm
Design Internal Pressure	Dp	3.500	kgf/cm ²
Include Pressure Thrust		No	
Vessel Centerline Direction Cosine	Vx	0.000	
Vessel Centerline Direction Cosine	Vy	1.000	
Vessel Centerline Direction Cosine	Vz	0.000	
Nozzle Centerline Direction Cosine	Nx	1.000	
Nozzle Centerline Direction Cosine	Ny	0.000	
Nozzle Centerline Direction Cosine	Nz	0.000	
Global Force (SUS)	Fx	0.0	kgf
Global Force (SUS)	Fy	7884.2	kgf
Global Force (SUS)	Fz	0.0	kgf
Global Moment (SUS)	Mx	0.0	kgf-m.
Global Moment (SUS)	My	0.0	kgf-m.
Global Moment (SUS)	Mz	457.5	kgf-m.

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Leg Check, (Operating Case): Step: 19 3:11pm Jul 28,2023

Internal Pressure (SUS)	P	3.50	kgf/cm ²
Include Pressure Thrust		No	

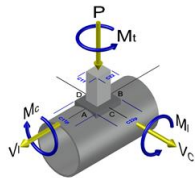
Global Force (OCC)	Fx	5697.6	kgf
Global Force (OCC)	Fy	3952.9	kgf
Global Force (OCC)	Fz	0.0	kgf
Global Moment (OCC)	Mx	0.0	kgf-m.
Global Moment (OCC)	My	0.0	kgf-m.
Global Moment (OCC)	Mz	229.4	kgf-m.

Occasional Internal Pressure (OCC)	Pvar	0.00	kgf/cm ²
------------------------------------	------	------	---------------------

Use Interactive Control	No
WRC107 Version	Version March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No
Local Loads applied at end of Nozzle/Attachment	No

WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



WRC 107/537 has dimensional limitations that can be found in the bulletin's Foreword and which can also be inferred by review of the non-dimensional curve limits.

WRC 107 Stress Calculation for SUSained loads:

Radial Load	P	0.0	kgf
Circumferential Shear	VC	0.0	kgf
Longitudinal Shear	VL	7884.2	kgf
Circumferential Moment	MC	0.0	kgf-m.
Longitudinal Moment	ML	-457.5	kgf-m.
Torsional Moment	MT	0.0	kgf-m.

Dimensionless Parameters used : Gamma = 60.17

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.119	4C	9.600	(A,B)
N(PHI) / (P/Rm)	0.119	3C	7.394	(C,D)
M(PHI) / (P)	0.119	2C1	0.058	(A,B)
M(PHI) / (P)	0.119	1C	0.092	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.119	3A	2.279	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.130	1A	0.083	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.119	3B	6.957	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.122	1B	0.035	(A,B,C,D)
N(x) / (P/Rm)	0.119	3C	7.400	(A,B)

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Leg Check, (Operating Case): Step: 19 3:11pm Jul 28,2023

N(x)	/ (P/Rm)	0.119	4C	9.603	(C,D)
M(x)	/ (P)	0.119	1C1	0.096	(A,B)
M(x)	/ (P)	0.119	2C	0.058	(C,D)
N(x)	/ (MC/(Rm**2 * Beta))	0.119	4A	3.663	(A,B,C,D)
M(x)	/ (MC/(Rm * Beta))	0.141	2A	0.040	(A,B,C,D)
N(x)	/ (ML/(Rm**2 * Beta))	0.119	4B	2.235	(A,B,C,D)
M(x)	/ (ML/(Rm * Beta))	0.125	2B	0.049	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (kgf/cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML		72.3	72.3	-72.3	-72.3	0.0	0.0	0.0	0.0
Circ. Bend. ML		141.4	-141.4	-141.4	141.4	0.0	0.0	0.0	0.0
Tot. Circ. Str.		213.6	-69.1	-213.6	69.1	0.0	0.0	0.0	0.0
Long. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML		22.8	22.8	-22.8	-22.8	0.0	0.0	0.0	0.0
Long. Bend. ML		193.8	-193.8	-193.8	193.8	0.0	0.0	0.0	0.0
Tot. Long. Str.		216.6	-171.1	-216.6	171.1	0.0	0.0	0.0	0.0
Shear VC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL		0.0	0.0	0.0	0.0	-62.4	-62.4	62.4	62.4
Shear MT		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear		0.0	0.0	0.0	0.0	-62.4	-62.4	62.4	62.4
Str. Int.		216.6	171.1	216.6	171.1	124.8	124.8	124.8	124.8

Dimensionless Parameters used : Gamma = 139.72

Dimensionless Loads for Cylindrical Shells at Pad Edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.141	4C	17.107	(A,B)
N(PHI) / (P/Rm)	0.141	3C	9.077	(C,D)
M(PHI) / (P)	0.151	2C1	0.023	(A,B)
M(PHI) / (P)	0.151	1C !	0.069	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.148	3A	5.087	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.156	1A	0.063	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.137	3B	12.335	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.141	1B	0.017	(A,B,C,D)
N(x) / (P/Rm)	0.150	3C	8.315	(A,B)
N(x) / (P/Rm)	0.150	4C	16.523	(C,D)
M(x) / (P)	0.145	1C1	0.052	(A,B)

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M(x)	/ (P)	0.145	2C	!	0.039	(C,D)
N(x)	/ (MC/(Rm**2 * Beta))	0.148	4A		11.625	(A,B,C,D)
M(x)	/ (MC/(Rm * Beta))	0.161	2A		0.026	(A,B,C,D)
N(x)	/ (ML/(Rm**2 * Beta))	0.137	4B		5.427	(A,B,C,D)
M(x)	/ (ML/(Rm * Beta))	0.140	2B		0.022	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (kgf/ cm²)

		Stress Intensity Values at							
Type of Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML		277.2	277.2	-277.2	-277.2	0.0	0.0	0.0	0.0
Circ. Bend. ML		327.3	-327.3	-327.3	327.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.		604.5	-50.1	-604.5	50.1	0.0	0.0	0.0	0.0
Long. Memb. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML		98.7	98.7	-98.7	-98.7	0.0	0.0	0.0	0.0
Long. Bend. ML		419.6	-419.6	-419.6	419.6	0.0	0.0	0.0	0.0
Tot. Long. Str.		518.2	-320.9	-518.2	320.9	0.0	0.0	0.0	0.0
Shear VC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL		0.0	0.0	0.0	0.0	-136.9	-136.9	136.9	136.9
Shear MT		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear		0.0	0.0	0.0	0.0	-136.9	-136.9	136.9	136.9
Str. Int.		604.5	320.9	604.5	320.9	273.8	273.8	273.8	273.8

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	5697.6	kgf
Circumferential Shear	VC	0.0	kgf
Longitudinal Shear	VL	3952.9	kgf
Circumferential Moment	MC	0.0	kgf-m.
Longitudinal Moment	ML	-229.4	kgf-m.
Torsional Moment	MT	0.0	kgf-m.

Dimensionless Parameters used : Gamma = 60.17

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (kgf/ cm²)

		Stress Intensity Values at							
Type of Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl

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Circ. Memb. P	-206.1	-206.1	-206.1	-206.1	-158.8	-158.8	-158.8	-158.8
Circ. Bend. P	-450.6	450.6	-450.6	450.6	-714.3	714.3	-714.3	714.3
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	36.2	36.2	-36.2	-36.2	0.0	0.0	0.0	0.0
Circ. Bend. ML	70.9	-70.9	-70.9	70.9	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-549.6	209.8	-763.9	279.1	-873.0	555.5	-873.0	555.5
Long. Memb. P	-158.9	-158.9	-158.9	-158.9	-206.2	-206.2	-206.2	-206.2
Long. Bend. P	-745.5	745.5	-745.5	745.5	-451.3	451.3	-451.3	451.3
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	11.4	11.4	-11.4	-11.4	0.0	0.0	0.0	0.0
Long. Bend. ML	97.2	-97.2	-97.2	97.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	-795.8	500.8	-1013.0	672.4	-657.5	245.1	-657.5	245.1
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-31.3	-31.3	31.3	31.3
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-31.3	-31.3	31.3	31.3
Str. Int.	795.8	500.8	1013.0	672.4	877.5	558.6	877.5	558.6

Dimensionless Parameters used : Gamma = 139.72

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (kgf/ cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		-861.2	-861.2	-861.2	-861.2	-457.0	-457.0	-457.0	-457.0
Circ. Bend. P		-954.9	954.9	-954.9	954.9	-2930.8	2930.8	-2930.8	2930.8
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML		139.0	139.0	-139.0	-139.0	0.0	0.0	0.0	0.0
Circ. Bend. ML		164.1	-164.1	-164.1	164.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.		-1513.0	68.6	-2119.2	118.8	-3387.7	2473.8	-3387.7	2473.8
Long. Memb. P		-418.6	-418.6	-418.6	-418.6	-831.8	-831.8	-831.8	-831.8
Long. Bend. P		-2179.9	2179.9	-2179.9	2179.9	-1632.6	1632.6	-1632.6	1632.6
Long. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML		49.5	49.5	-49.5	-49.5	0.0	0.0	0.0	0.0
Long. Bend. ML		210.4	-210.4	-210.4	210.4	0.0	0.0	0.0	0.0
Tot. Long. Str.		-2338.7	1600.4	-2858.3	1922.2	-2464.4	800.7	-2464.4	800.7
Shear VC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL		0.0	0.0	0.0	0.0	-68.6	-68.6	68.6	68.6
Shear MT		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear		0.0	0.0	0.0	0.0	-68.6	-68.6	68.6	68.6
Str. Int.		2338.7	1600.4	2858.3	1922.2	3392.8	2476.6	3392.8	2476.6

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DECOKING DRUM

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Leg Check, (Operating Case): Step: 19 3:11pm Jul 28,2023

WRC 107/ 537 Stress Summations:

Vessel Stress Summation at Attachment Junction (kgf/cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		207.1	210.6	207.1	210.6	207.1	210.6	207.1	210.6
Circ. Pm (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)		207.1	210.6	207.1	210.6	207.1	210.6	207.1	210.6
Circ. Pl (SUS)		72.3	72.3	-72.3	-72.3	0.0	0.0	0.0	0.0
Circ. Pl (OCC)		-169.9	-169.9	-242.4	-242.4	-158.8	-158.8	-158.8	-158.8
Circ. Pl(TOTAL)		-97.6	-97.6	-314.7	-314.7	-158.8	-158.8	-158.8	-158.8
Circ. Q (SUS)		141.4	-141.4	-141.4	141.4	0.0	0.0	0.0	0.0
Circ. Q (OCC)		-379.7	379.7	-521.5	521.5	-714.3	714.3	-714.3	714.3
Circ. Q (TOTAL)		-238.4	238.4	-662.8	662.8	-714.3	714.3	-714.3	714.3
Long. Pm (SUS)		103.5	103.5	103.5	103.5	103.5	103.5	103.5	103.5
Long. Pm (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)		103.5	103.5	103.5	103.5	103.5	103.5	103.5	103.5
Long. Pl (SUS)		22.8	22.8	-22.8	-22.8	0.0	0.0	0.0	0.0
Long. Pl (OCC)		-147.5	-147.5	-170.3	-170.3	-206.2	-206.2	-206.2	-206.2
Long. Pl(TOTAL)		-124.7	-124.7	-193.1	-193.1	-206.2	-206.2	-206.2	-206.2
Long. Q (SUS)		193.8	-193.8	-193.8	193.8	0.0	0.0	0.0	0.0
Long. Q (OCC)		-648.3	648.3	-842.7	842.7	-451.3	451.3	-451.3	451.3
Long. Q (TOTAL)		-454.5	454.5	-1036.5	1036.5	-451.3	451.3	-451.3	451.3
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		0.0	0.0	0.0	0.0	-62.4	-62.4	62.4	62.4
Shear Pl (OCC)		0.0	0.0	0.0	0.0	-31.3	-31.3	31.3	31.3
Shear Pl(TOTAL)		0.0	0.0	0.0	0.0	-93.6	-93.6	93.6	93.6
Shear Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)		207.1	210.6	207.1	210.6	207.1	210.6	207.1	210.6
Pm (SUS+OCC)		207.1	210.6	207.1	210.6	207.1	210.6	207.1	210.6
Pm+Pl (SUS)		279.4	282.9	134.8	138.3	236.4	239.3	236.4	239.3
Pm+Pl (SUS+OCC)		130.7	134.2	107.6	104.1	240.6	242.8	240.6	242.8
Pm+Pl+Q (Total)		475.7	433.3	1126.1	947.0	719.1	786.1	719.1	786.1

Vessel Stress Summation Comparison (kgf/cm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	210.60	1310.01	Passed
Pm (SUS+OCC)	210.60	1572.01	Passed
Pm+Pl (SUS)	282.89	1965.02	Passed
Pm+Pl (SUS+OCC)	242.79	2358.02	Passed
Pm+Pl+Q (TOTAL)	1126.08	3931.72	Passed

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Leg Check, (Operating Case): Step: 19 3:11pm Jul 28,2023

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

WRC 107/ 537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (kgf/cm²)

Type of Stress	Load	Stress Intensity Values at							
		Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		485.5	489.0	485.5	489.0	485.5	489.0	485.5	489.0
Circ. Pm (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)		485.5	489.0	485.5	489.0	485.5	489.0	485.5	489.0
Circ. Pl (SUS)		277.2	277.2	-277.2	-277.2	0.0	0.0	0.0	0.0
Circ. Pl (OCC)		-722.2	-722.2	-1000.2	-1000.2	-457.0	-457.0	-457.0	-457.0
Circ. Pl(TOTAL)		-445.0	-445.0	-1277.5	-1277.5	-457.0	-457.0	-457.0	-457.0
Circ. Q (SUS)		327.3	-327.3	-327.3	327.3	0.0	0.0	0.0	0.0
Circ. Q (OCC)		-790.8	790.8	-1119.0	1119.0	-2930.8	2930.8	-2930.8	2930.8
Circ. Q (TOTAL)		-463.5	463.5	-1446.3	1446.3	-2930.8	2930.8	-2930.8	2930.8
Long. Pm (SUS)		242.8	242.8	242.8	242.8	242.8	242.8	242.8	242.8
Long. Pm (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)		242.8	242.8	242.8	242.8	242.8	242.8	242.8	242.8
Long. Pl (SUS)		98.7	98.7	-98.7	-98.7	0.0	0.0	0.0	0.0
Long. Pl (OCC)		-369.1	-369.1	-468.1	-468.1	-831.8	-831.8	-831.8	-831.8
Long. Pl(TOTAL)		-270.5	-270.5	-566.8	-566.8	-831.8	-831.8	-831.8	-831.8
Long. Q (SUS)		419.6	-419.6	-419.6	419.6	0.0	0.0	0.0	0.0
Long. Q (OCC)		-1969.5	1969.5	-2390.2	2390.2	-1632.6	1632.6	-1632.6	1632.6
Long. Q (TOTAL)		-1549.9	1549.9	-2809.8	2809.8	-1632.6	1632.6	-1632.6	1632.6
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		0.0	0.0	0.0	0.0	-136.9	-136.9	136.9	136.9
Shear Pl (OCC)		0.0	0.0	0.0	0.0	-68.6	-68.6	68.6	68.6
Shear Pl(TOTAL)		0.0	0.0	0.0	0.0	-205.5	-205.5	205.5	205.5
Shear Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)		485.5	489.0	485.5	489.0	485.5	489.0	485.5	489.0
Pm (SUS+OCC)		485.5	489.0	485.5	489.0	485.5	489.0	485.5	489.0
Pm+Pl (SUS)		762.8	766.3	208.3	211.8	547.1	550.0	547.1	550.0
Pm+Pl (SUS+OCC)		68.2	71.7	791.9	788.4	741.9	744.8	741.9	744.8
Pm+Pl+Q (Total)		1577.6	1522.2	3133.8	2485.8	2959.4	2984.6	2959.4	2984.6

Vessel Stress Summation Comparison (kgf/cm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	489.03	1310.01	Passed

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Leg Check, (Operating Case): Step: 19 3:11pm Jul 28,2023

Pm (SUS+OCC)	489.03	1572.01	Passed
Pm+Pl (SUS)	766.27	1965.02	Passed
Pm+Pl (SUS+OCC)	791.93	2358.02	Passed
Pm+Pl+Q (TOTAL)	3133.81	3931.72	Passed

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

Bolting Size Requirement for Leg Baseplates :

Baseplate Material	SA/IS 2062
Baseplate Allowable Stress	SBA 1195.20 kgf/cm ²
Baseplate Length	B 500.0000 mm
Baseplate Width	D 500.0000 mm
Baseplate Thickness	BTHK 25.0000 mm
Leg Dimension Along Baseplate Length	d 299.9994 mm
Leg Dimension Along Baseplate Width	b 139.9997 mm
Dist. from the Leg Edge to Bolt Hole Center	z 2680.0000 mm
Bolt Material	SA/IS 2062
Bolt Allowable Tensile Stress	STBA 1195.20 kgf/cm ²
Bolt Allowable Shear Stress	SBShear 295.29 kgf/cm ²
Anchor Bolt Nominal Diameter	BOD 39.0000 mm
Number of Anchor Bolts in Tension per Leg	NB 1
Total Number of Anchors Bolt per Leg	NBT 2
Bolt Corrosion Allowance	bca 1.5000 mm
Ultimate 28-day Concrete Strength	FCPRIME 210.921 kgf/cm ²

Warning: Dim., B is too short for the leg size (500.00)

Warning: Dimension, D is too short for the leg size (500.00)

Computing the required bolt area based on a standard method not including the baseplate's interaction with the foundation.

Calculation of Load per Bolt, Wind Empty [W,wind]:

$$\begin{aligned}
 &= ((4 * \text{Moment}/\text{BCD}) - \text{Weight}) / \text{Num Bolts} \\
 &= ((4 * 3756/2680.0) - 12217) / 8 \\
 &= -826.251 \text{ kgf}
 \end{aligned}$$

Calculation of Load per Bolt, Seismic Operating [W,seismic]:

$$\begin{aligned}
 &= ((4 * \text{Moment}/\text{BCD}) - \text{Weight}) / \text{Num Bolts} \\
 &= ((4 * 10436/2680.0) - 16375) / 8 \\
 &= -99.878 \text{ kgf}
 \end{aligned}$$

There was a vertical load reducing the weight on the support.

Note: The bolts are not loaded in tension.

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DECOKING DRUM

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FileName : Decoking Drum_R0-28072023 -----

Conical Section: ToriCone Cone: 5 3:11pm Jul 28,2023

Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Input Values:

ToriCone

Design Internal Pressure, Small End		3.844	kgf/cm ²
Design Internal Pressure, Large End		3.680	kgf/cm ²
Temperature for Internal Pressure		350.0	°C
Design External Pressure		1.055	kgf/cm ²
Temperature for External Pressure		150.0	°C
Cone Material		SA-516 70	
Cone Allowable Stress at Temperature	Ss	1310.01	kgf/cm ²
Cone Allowable Stress At Ambient		1406.14	kgf/cm ²
Longitudinal Joint Efficiency of Cone		1.00	
Circumferential Joint Efficiency of Cone		1.00	
Actual Thickness of Cone	Tc	11.0000	mm
Corrosion Allowance for Cone	Cac	3.0000	mm
Diameter Basis for Cone and Cylinders		ID	
Diameter of Small End of Cone	Ds	355.600	mm
Diameter of Large End of Cone	Dl	2500.000	mm
Half Apex Angle for Cone		30.00	degrees
Axial Length of Cone	Lc	1153.000	mm
Small End Cylinder Material		SA-105	
Small Cylinder Allowable Stress at Operating	Ss	1310.01	kgf/cm ²
Small Cylinder Allowable Stress At Ambient		1406.14	kgf/cm ²
Joint Efficiency of Small Cylinder	Es	1.0000	
Actual Thickness of Small Cylinder	Ts	11.0000	mm
Corrosion Allowance for Small Cylinder	Cas	3.0000	mm
Axial Length of Small Cylinder	Ls	127.000	mm
Large End Cylinder Material		SA-516 70	
Large Cylinder Allowable Stress at Operating	Sl	1310.01	kgf/cm ²
Large Cylinder Allowable Stress At Ambient		1406.14	kgf/cm ²
Joint Efficiency of Large Cylinder	El	1.0000	
Actual Thickness of Large Cylinder	Tl	12.0000	mm
Corrosion Allowance for Large Cylinder	Cal	3.0000	mm
Axial Length of Large Cylinder	Ll	1673.000	mm
Type of Reinforcement at Large End of Cone:		Knuckle	
Large End Reinforcing/Knuckle Material		None	
Large Reinforcing/Knuckle Allowable, Operating		1310.01	kgf/cm ²
Large Reinforcing/Knuckle Allowable, Ambient		1406.14	kgf/cm ²
Bend Radius for Knuckle at Large End	Rblk	250.0000	mm
Thickness for Knuckle at Large End	Rtlk	12.0000	mm
Type of Reinforcement at Small End of Cone:		Knuckle	
Small End Reinforcing/Knuckle Material		None	
Small Reinforcing/Knuckle Allowable, Operating		1310.01	kgf/cm ²
Small Reinforcing/Knuckle Allowable, Ambient		1406.14	kgf/cm ²
Bend Radius for Knuckle at Small End	Rbsk	35.6000	mm
Thickness for Knuckle at Small End	Rtsk	12.0000	mm
Force Arl & Ars calculation, cone -> flange		No	
Force Arl & Ars calculation, cone -> cylinder		No	

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Conical Section: ToriCone Cone: 5 3:11pm Jul 28,2023

Calculated Values:

Elastic Modulus Data from ASME Section II Part D at 150 °C

Elastic Modulus of Cone Material	0.199E+07 kgf/cm ² at 150 °C
Elastic Modulus of Small Cylinder Material	0.199E+07 kgf/cm ² at 150 °C
Elastic Modulus of Large Cylinder Material	0.199E+07 kgf/cm ² at 150 °C

Elastic Modulus Data from ASME Section II Part D at 350 °C

Elastic Modulus of Cone Material	0.182E+07 kgf/cm ² at 350 °C
Elastic Modulus of Small Cylinder Material	0.182E+07 kgf/cm ² at 350 °C
Elastic Modulus of Large Cylinder Material	0.182E+07 kgf/cm ² at 350 °C

Forces and Moments on the ends of the Cone:

Axial Force on Small End of Cone	-398.06 kgf
Axial Force on Large End of Cone	-12931.41 kgf
Moment on Small End of Cone	14.64 kgf-m.
Moment on Large End of Cone	2097.02 kgf-m.

The moments above are computed from the Wind & Seismic loads as well as any user defined moments and include effects due to eccentric masses. The vertical forces include the weight of the elements and details above and below the cone as well as any user defined vertical forces. Vertical forces also include loads cause from vertical accelerations due to earthquake loading.

Note: Neither end of Cone is a Line of Support

Maximum Centroid Reinforcement Distance Large End	26.6435 mm
Maximum Centroid Reinforcement Distance Small End	9.7160 mm

Note: No ring was found close enough to the large end to be considered.**Note: No ring was found close enough to the small end to be considered.****Thickness and Maximum Pressure for Large Knuckle:**

Large End Knuckle Thickness	12.000 mm
Large End Knuckle Radius	250.000 mm
Corrosion Allowance	3.000 mm

% Elongation per Table UG-79-1 $(75 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$: 3.516 %**Thickness Due to Internal Pressure [Tr]:**

$$= (P \cdot (L + ca) \cdot M) / (2 \cdot S \cdot E - 0.2 \cdot P) + ca \text{ per App. 1-4 (d)}$$

$$= (3.68 (1407.7006) \cdot 1.34) / (2 \cdot 1310 \cdot 1.0 - 0.2 \cdot 3.68)$$

$$= \max(5.6496, 9.8082) \text{ per UG-33 (f)}$$

$$= 9.8082 \text{ mm}$$
Equivalent Crown Radius [L]:

$$= D_i / (2 \cdot (\cos(\alpha))) + ca \text{ per UG-32 (h)}$$

$$= 2433.01 / (2 \cdot (\cos(30.0))) + 3.0$$

$$= 1407.7006 \text{ mm}$$
Stress Concentration Factor [M]:

$$= (3 + \sqrt{L / (r + ca)}) / 4$$

$$= (3 + \sqrt{1407.7 / (250.0 + 3.0)}) / 4$$

$$= 1.3397$$
Maximum Allowable Working Pressure at Given Thickness:

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FileName : Decoking Drum_R0-28072023 -----

Conical Section: ToriCone Cone: 5 3:11pm Jul 28,2023

$$= (2 * S * E (t - ca)) / (M (L + ca) + 0.2 (t - ca)) \text{ per Appendix 1-4 (d)}$$

$$= (2 * 1310 * 1.0 (12.0 - 3.0)) / (1.34 (1407.7006 + 3.0) + 0.2 (12.0 - 3.0))$$

$$= 12.491 - 0.180 = 12.312 \text{ kgf/cm}^2$$

Required Thickness for Small Knuckle:

Small End Knuckle Thickness	12.000	mm
Small End Knuckle Radius	35.600	mm
Corrosion Allowance	3.000	mm
Minimum Required Small End Thickness	4.588	mm

% Elongation per Table UG-79-1 $(75 * t_{nom} / R_f) * (1 - R_f / R_o)$: 21.635 %*Warning: Please Check Requirements of UCS-79 as Elongation is > 5%***Force per Length, Cone Small End [QS]:**

$$= P_{ext} (R_s / 2) + f_2$$

$$= 1.055 (188.8 / 2) + -0.21$$

$$= 0.789 \text{ kgf/mm}$$

Axial Load per Unit Circumference excluding Pressure [f2]:

$$= F_{axial} / (\pi (D_s + T_s)) + \text{Moment} / (\pi (R_s + T_s / 2) (R_s + T_s / 2))$$

$$= +398.1 / (\pi (377.6 - 11.0)) + 14.6 / (\pi (188.8 - 11.0 / 2) (188.8 - 11.0 / 2))$$

$$= -0.2 \text{ kgf/mm}$$

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure kgf/cm ²	Reason for Failure at this Pressure
MAWP	7.242	Thickness due to internal pressure, Cone Large End
MAPnc	10.966	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N5-100-SEAL Nozl: 17 3:11pm Jul 28,2023

Input, Nozzle Desc: N5-100-SEAL

From: 20

Pressure for Reinforcement Calculations	P	3.724	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Cone at Nozzle Location	D	2115.47	mm
Equivalent Length of Conical Section	Le	1672.9998	mm
Cone Half Apex Angle	Alpha	30.00	Degrees
Shell Finished (Minimum) Thickness	t	11.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		88.64	cm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	1177.10	kgf/cm ²
Allowable Stress At Ambient	Sna	1202.20	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		315.00	deg
Diameter		4.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness		80	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	11.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	1310.01	kgf/cm ²
Pad Allowable Stress At Ambient	Spa	1406.14	kgf/cm ²
Diameter of Pad along vessel surface	Dp	278.2750	mm
Thickness of Pad	te	12.0000	mm
Weld leg size between Pad and Shell	Wp	10.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm
Reinforcing Pad Width		81.9875	mm
User Defined Nozzle/Shell Centerline Angle		90.0000	deg.
Flange Class		150	

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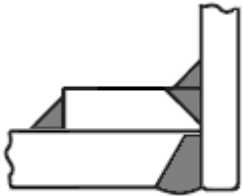
FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N5-100-SEAL Nozl: 17 3:11pm Jul 28,2023

Flange Grade

GR 1.1

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)**Insert/Set-in Nozzle With Pad, no Inside projection****Reinforcement CALCULATION, Description: N5-100-SEAL**

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	4.500 in.
Actual Thickness Used in Calculation	0.337 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Conical Transition, tr [Int. Press]

$$= P \cdot D / (2 \cdot \cos(a) \cdot (S_v \cdot E - 0.6 \cdot P)) \text{ Appendix 1-4 (e)}$$

$$= 3.72 (2122.3984 + 2 \cdot 0.866) / (2 \cdot 1310.0122 (1 \cdot 3.72 - 0.6 \cdot 2)) \#$$

$$= 3.4892 \text{ mm}$$

Reqd Cone thickness at Nozzle Location under External Pres. : 9.6904 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]

$$= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)}$$

$$= 3.72 \cdot 57.15 / (1177 \cdot 1.0 + 0.4 \cdot 3.72)$$

$$= 0.1806 \text{ mm}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.4104 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	238.2849	mm
Parallel to Vessel Wall, opening length	d	119.1425	mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		20.0000	mm

The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 1177.1 / 1310.0)$$

$$= 0.899$$

Weld Strength Reduction Factor [fr2]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 1177.1 / 1310.0)$$

$$= 0.899$$

Weld Strength Reduction Factor [fr4]:

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Nozzle Calcs.: N5-100-SEAL Nozl: 17 3:11pm Jul 28,2023

$$\begin{aligned}
 &= \min(1, Sp/Sv) \\
 &= \min(1, 1310.0/1310.0) \\
 &= 1.000
 \end{aligned}$$

Weld Strength Reduction Factor [fr3]:

$$\begin{aligned}
 &= \min(fr2, fr4) \\
 &= \min(0.899, 1.) \\
 &= 0.899
 \end{aligned}$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	4.197	4.023	NA
Area in Shell	A1	0.000	0.000	NA
Area in Nozzle Wall	A2	0.000	0.000	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.863	0.863	NA
Area in Element	A5	12.756	12.756	NA
TOTAL AREA AVAILABLE	Atot	13.619	13.619	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 60.00 Degr.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	142.0828	12.0000 mm
Based on given Pad Diameter:	278.2751	3.1363 mm
Based on Shell or Nozzle Thickness:	170.9310	8.5598 mm

Area Required [A]:

$$\begin{aligned}
 &= (d * tr * F + 2 * tn * tr * F * (1 - fr1)) \text{ UG-37(c)} \\
 &= (119.1425 * 3.4892 * 1.0 + 2 * 5.5598 * 3.4892 * 1.0 * (1 - 0.9)) \\
 &= 4.197 \text{ cm}^2
 \end{aligned}$$

The area in the shell has not been calculated by user request.

The area in the nozzle wall has not been calculated by user request.

Area 2wp has not been Calculated by User Request.

Area Available in Welds [A41 + A42 + A43]:

$$\begin{aligned}
 &= (Wo^2 - Ar \text{ Lost}) * Fr3 + ((Wi - can / 0.707)^2 - Ar \text{ Lost}) * fr2 + Wp^2 * fr4 \\
 &= (0.96) * 0.9 + (0.0) * 0.9 + 0.0^2 * 1. \\
 &= 0.863 \text{ cm}^2
 \end{aligned}$$

Area Available in Element [A5]:

$$\begin{aligned}
 &= (\min(Dp, DL) - (\text{Nozzle OD})) * (\min(tp, Tlwp, te)) * fr4 \\
 &= (238.2849 - 131.9823) * 12.0 * 1. \\
 &= 12.756 \text{ cm}^2
 \end{aligned}$$

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.4104 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 6.4892 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 6.4892 mm
Wall Thickness, shell/head, external pressure	trb2 = 3.9869 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N5-100-SEAL Nozl: 17 3:11pm Jul 28,2023

Wall Thickness per table UG-45

tb3 = 8.2578 mm

Determine Nozzle Thickness candidate [tb]:

$= \min[tb3, \max(tb1, tb2)]$
 $= \min[8.258, \max(6.4892, 4.5)]$
 $= 6.4892 \text{ mm}$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$= \max(ta, tb)$
 $= \max(3.4104, 6.4892)$
 $= 6.4892 \text{ mm}$

Available Nozzle Neck Thickness = $0.875 * 8.560 = 7.490 \text{ mm}$ --> OK**Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:****Nozzle Neck to Flange Weld, min(Curve:C, Curve:B)**

Govrn. thk, tg = 7.49, tr = 0.177, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E*/(tg - c) = 0.039$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: C

Govrn. thk, tg = 7.49, tr = 0.177, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E*/(tg - c) = 0.039$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B

Govrn. thk, tg = 7.49, tr = 0.177, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E*/(tg - c) = 0.039$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -29 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Shell to Pad Weld Junction at Pad OD, min(Curve:B, Curve:D)

Govrn. thk, tg = 11.0, tr = 3.25, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E*/(tg - c) = 0.406$, Temp. Reduction = 49 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -26 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -48 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:C, Curve:D)

Govrn. thk, tg = 7.49, tr = 0.177, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E*/(tg - c) = 0.039$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C -48 °C
 Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the Nozzle : -104 °C
 Gov. MDMT of the Reinforcement Pad : -48 °C
 Gov. MDMT of the nozzle to shell joint welded assembly : -48 °C

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N5-100-SEAL Nozl: 17 3:11pm Jul 28,2023

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c) -18 °C
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $3.72/19.99 = 0.186$ Weld Size Calculations. Description: N5-100-SEAL

Intermediate Calc. for nozzle/shell Welds Tmin 5.5598 mm
 Intermediate Calc. for pad/shell Welds TminPad 9.0000 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$3.8919 = 0.7 * t_{min}$	$7.0700 = 0.7 * W_o$ mm
Pad Weld	$4.5000 = 0.5 * T_{minPad}$	$7.0700 = 0.7 * W_p$ mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) * S_v)$$

$$= \max(0, (4.1965 - 0.0 + 2 * 5.5598 * 0.8985 * (1.0 * 8.0 - 3.4892)) * 1310)$$

$$= 6087.90 \text{ kgf}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - C_{an} / .707)^2 * f_{r2}) * S_v$$

$$= (0.0 + 12.7563 + 0.8626 - 0.0 * 0.9) * 1310$$

$$= 17840.90 \text{ kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (0.0 + 0.0 + 0.8985 + (0.7993)) * 1310$$

$$= 2224.21 \text{ kgf}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (0.0 + 0.0 + 0.8626 + 12.7563 + (0.7993)) * 1310$$

$$= 18888.01 \text{ kgf}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Snw]:

$$= (\pi/2) * D_{lo} * W_o * 0.49 * S_{nw}$$

$$= (3.1416/2.0) * 131.9823 * 10.0 * 0.49 * 1177$$

$$= 11958. \text{ kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * D_P * W_P * 0.49 * S_{EW}$$

$$= (3.1416/2.0) * 278.275 * 10.0 * 0.49 * 1310$$

$$= 28058. \text{ kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - C_{an}) * 0.7 * S_n$$

$$= (3.1416 * 62.7812) * (8.5598 - 3.0) * 0.7 * 1177$$

$$= 9035. \text{ kgf}$$

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DECOKING DRUM**PV Elite 24 Licensee: #BHEL-HPVP-Vizag****FileName : Decoking Drum_R0-28072023 -----****Nozzle Calcs.: N5-100-SEAL Nozl: 17 3:11pm Jul 28,2023**

Tension, Pad Groove Weld [Tpgw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg} \\
 &= (3.1416/2) * 131.9823 * 12.0 * 0.74 * 1310 \\
 &= 24117. \text{ kgf}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (T - c_{as}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 131.9823 * (11.0 - 3.0) * 0.74 * 1310 \\
 &= 16078. \text{ kgf}
 \end{aligned}$$

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:

$$= (S_{PEW} + S_{NW}) = (28058 + 9035) = 37094 \text{ kgf}$$

Failure Path [Path 2-2]:

$$\begin{aligned}
 &= (S_{onw} + T_{pgw} + T_{ngw} + S_{inw}) \\
 &= (11958 + 24117 + 16078 + 0) = 52153 \text{ kgf}
 \end{aligned}$$

Failure Path [Path 3-3]:

$$\begin{aligned}
 &= (S_{pew} + T_{ngw} + S_{inw}) \\
 &= (28058 + 16078 + 0) = 44136 \text{ kgf}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 37093	kgf, must exceed W = 6087 kgf	or W1 = 17840 kgf
Path 2-2 = 52152	kgf, must exceed W = 6087 kgf	or W2 = 2224 kgf
Path 3-3 = 44136	kgf, must exceed W = 6087 kgf	or W3 = 18888 kgf

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 5 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure: 1 kgf/cm²

The Drop for this Nozzle is : 1.5451 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 162.5451 mm

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: M-600-MH Nozl: 18 3:11pm Jul 28,2023

Input, Nozzle Desc: M-600-MH**From: 30**

Pressure for Reinforcement Calculations	P	3.500	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Cylindrical Shell	D	2500.00	mm
Design Length of Section	L	2480.0002	mm
Shell Finished (Minimum) Thickness	t	12.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		248.63	cm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material [Normalized]		SA-516 70	
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	1310.00	kgf/cm ²
Allowable Stress At Ambient	Sna	1406.10	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		24.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.0000	mm
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	1310.00	kgf/cm ²
Pad Allowable Stress At Ambient	Spa	1406.10	kgf/cm ²
Diameter of Pad along vessel surface	Dp	1209.6000	mm
Thickness of Pad	te	12.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm
Reinforcing Pad Width		300.0000	mm
This is a Manway or Access Opening.			
Flange Class		150	
Flange Grade		GR 1.1	

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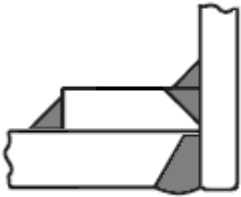
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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: M-600-MH Nozl: 18 3:11pm Jul 28,2023

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: M-600-MH

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	24.000 in.
Actual Thickness Used in Calculation	0.472 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]

$$\begin{aligned}
 &= P \cdot R / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)} \\
 &= 3.5 \cdot 1253.0 / (1310 \cdot 1.0 - 0.6 \cdot 3.5) \\
 &= 3.3531 \text{ mm}
 \end{aligned}$$

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]

$$\begin{aligned}
 &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)} \\
 &= 3.5 \cdot 304.8 / (1310 \cdot 1.0 + 0.4 \cdot 3.5) \\
 &= 0.8135 \text{ mm}
 \end{aligned}$$

Required Nozzle thickness under External Pressure per UG-28 : 1.0872 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	1183.2001 mm
Parallel to Vessel Wall, opening length	d	591.6000 mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		22.5000 mm

The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 1310.0 / 1310.0) \\
 &= 1.000
 \end{aligned}$$

Weld Strength Reduction Factor [fr2]:

$$\begin{aligned}
 &= \min(1, S_n / S_v) \\
 &= \min(1, 1310.0 / 1310.0) \\
 &= 1.000
 \end{aligned}$$

Weld Strength Reduction Factor [fr4]:

$$\begin{aligned}
 &= \min(1, S_p / S_v) \\
 &= \min(1, 1310.0 / 1310.0) \\
 &= 1.000
 \end{aligned}$$

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: M-600-MH Nozl: 18 3:11pm Jul 28,2023

Weld Strength Reduction Factor [fr3]:

$$= \min(\text{fr2}, \text{fr4})$$

$$= \min(1., 1.)$$

$$= 1.000$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	19.837	23.776	NA
Area in Shell	A1	0.000	0.000	NA
Area in Nozzle Wall	A2	0.000	0.000	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		1.000	1.000	NA
Area in Element	A5	68.831	68.831	NA
TOTAL AREA AVAILABLE	Atot	69.831	69.831	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS: Diameter Thickness

Based on given Pad Thickness: 799.4042 12.0000 mm

Based on given Pad Diameter: 1209.6000 3.9708 mm

Based on Shell or Nozzle Thickness: 799.4042 12.0000 mm

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(591.6 * 8.038 * 1 + 2 * 9.0 * 8.038 * 1(1 - 1.))$$

$$= 23.776 \text{ cm}^2$$

The area in the shell has not been calculated by user request.

The area in the nozzle wall has not been calculated by user request.

Area 2wp has not been Calculated by User Request.

Area Available in Welds [A41 + A42 + A43]:

$$= W_o^2 * fr3 + (W_i - c_n / 0.707)^2 * fr2 + W_p^2 * fr4$$

$$= 10.0^2 * 1. + (0.0)^2 * 1. + 0.0^2 * 1.$$

$$= 1.000 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(D_p, D_L) - (\text{Nozzle OD})) * (\min(t_p, t_{lwp}, t_e)) * fr4$$

$$= (1183.2001 - 609.6) * 12.0 * 1.$$

$$= 68.831 \text{ cm}^2$$

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:**Nozzle Neck to Flange Weld, min(Curve:D, Curve:B)**

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.084, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -23 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: M-600-MH Nozl: 18 3:11pm Jul 28,2023

Nozzle Neck to Pad Weld for the Nozzle, Curve: D

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^* / (tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^* / (tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 12.0, tr = 3.123, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^* / (tg - c) = 0.347$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: D

Govrn. thk, tg = 12.0, tr = 3.123, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^* / (tg - c) = 0.347$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Gov. MDMT of the Nozzle	: -104 °C
Gov. MDMT of the Reinforcement Pad	: -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly	: -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b)	-104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $3.50/19.99 = 0.175$ **Weld Size Calculations. Description: M-600-MH**

Intermediate Calc. for nozzle/shell Welds	Tmin	9.0000	mm
Intermediate Calc. for pad/shell Welds	TminPad	9.0000	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$6.0000 = \text{Min per Code}$	$7.0700 = 0.7 * W_o \text{ mm}$
Pad Weld	$4.5000 = 0.5 * T_{minPad}$	$5.6560 = 0.7 * W_p \text{ mm}$

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max(0, (A - A_1 + 2 * t_n * f_{r1} * (E_1 * t - t_r)) S_v)$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: M-600-MH Nozl: 18 3:11pm Jul 28,2023

$$\begin{aligned}
 &= \max(0, (23.7763 - 0.0 + 2 * 9.0 * 1. * \\
 &\quad (1.0 * 9.0 - 8.038)) 1310) \\
 &= 31374.02 \text{ kgf}
 \end{aligned}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$\begin{aligned}
 &= (A2+A5+A4-(W_i-\text{Can}/.707)^2 * fr2) * Sv \\
 &= (0.0 + 68.8314 + 1. - 0.0 * 1.) * 1310 \\
 &= 91479.80 \text{ kgf}
 \end{aligned}$$

Weld Load [W2]:

$$\begin{aligned}
 &= (A2 + A3 + A4 + (2 * t_n * t * fr1)) * Sv \\
 &= (0.0 + 0.0 + 1. + (1.62)) * 1310 \\
 &= 3432.19 \text{ kgf}
 \end{aligned}$$

Weld Load [W3]:

$$\begin{aligned}
 &= (A2+A3+A4+A5+(2*t_n*t*fr1)) * S \\
 &= (0.0 + 0.0 + 1. + 68.8314 + (1.62)) * 1310 \\
 &= 93602.00 \text{ kgf}
 \end{aligned}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * W_o * 0.49 * S_{nw} \\
 &= (3.1416/2.0) * 609.6 * 10.0 * 0.49 * 1310 \\
 &= 61466. \text{ kgf}
 \end{aligned}$$

Shear, Pad Element Weld [Spew]:

$$\begin{aligned}
 &= (\pi/2) * D_P * W_P * 0.49 * S_{EW} \\
 &= (3.1416/2.0) * 1209.6 * 8.0 * 0.49 * 1310 \\
 &= 97570. \text{ kgf}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - \text{Can}) * 0.7 * S_n \\
 &= (3.1416 * 300.3) * (12.0 - 3.0) * 0.7 * 1310 \\
 &= 77860. \text{ kgf}
 \end{aligned}$$

Tension, Pad Groove Weld [Tpgw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg} \\
 &= (3.1416/2) * 609.6 * 12.0 * 0.74 * 1310 \\
 &= 111391. \text{ kgf}
 \end{aligned}$$

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (T - \text{cas}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 609.6 * (12.0 - 3.0) * 0.74 * 1310 \\
 &= 83544. \text{ kgf}
 \end{aligned}$$

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:

$$= (S_{PEW} + S_{NW}) = (97570 + 77860) = 175431 \text{ kgf}$$

Failure Path [Path 2-2]:

$$\begin{aligned}
 &= (S_{onw} + T_{pgw} + T_{ngw} + S_{inw}) \\
 &= (61466 + 111391 + 83544 + 0) = 256400 \text{ kgf}
 \end{aligned}$$

Failure Path [Path 3-3]:

$$= (S_{pew} + T_{ngw} + S_{inw})$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: M-600-MH Nozl: 18 3:11pm Jul 28,2023

$$= (97570 + 83544 + 0) = 181114 \text{ kgf}$$

Summary of Failure Path Calculations:

Path 1-1 = 175430 kgf, must exceed W = 31374 kgf or W1 = 91479 kgf

Path 2-2 = 256399 kgf, must exceed W = 31374 kgf or W2 = 3432 kgf

Path 3-3 = 181114 kgf, must exceed W = 31374 kgf or W3 = 93602 kgf

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Maximum Allowable Pressure in the Operating case: 9 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure: 1 kgf/cm²

The Drop for this Nozzle is : 37.7306 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 199.7307 mm

Percent Elongation Calculations:

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.008 %

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N7-50-Temp Gaug Nozl: 19 3:11pm Jul 28,2023

Input, Nozzle Desc: N7-50-Temp Gauge**From: 30**

Pressure for Reinforcement Calculations	P	3.596	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Cylindrical Shell	D	2500.00	mm
Design Length of Section	L	1672.9998	mm
Shell Finished (Minimum) Thickness	t	12.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		168.63	cm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	1177.10	kgf/cm ²
Allowable Stress At Ambient	Sna	1202.20	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

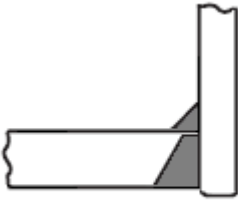
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PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N7-50-Temp Gaug Nozl: 19 3:11pm Jul 28,2023

**Insert/Set-in Nozzle No Pad, no Inside projection****Reinforcement CALCULATION, Description: N7-50-Temp Gauge**

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	2.375 in.
Actual Thickness Used in Calculation	0.344 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]

$$= P \cdot R / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)}$$

$$= 3.6 \cdot 1253.0 / (1310 \cdot 1.0 - 0.6 \cdot 3.6)$$

$$= 3.4451 \text{ mm}$$

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]

$$= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)}$$

$$= 3.6 \cdot 30.1625 / (1177 \cdot 1.0 + 0.4 \cdot 3.6)$$

$$= 0.0920 \text{ mm}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.2827 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	97.6996 mm
Parallel to Vessel Wall, opening length	d	48.8498 mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.3440 mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N7-50-Temp Gaug.
This calculation is valid for nozzles that meet all the requirements of
paragraph UG-36. Please check the Code carefully, especially for nozzles
that are not isolated or do not meet Code spacing requirements. To force
the computation of areas for small nozzles go to Tools->Configuration
and check the box to force the UG-37 small nozzle area calculation.

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.2827 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 6.4451 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 6.4451 mm
Wall Thickness, shell/head, external pressure	trb2 = 4.0092 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb3, \max(tb1, tb2)]$$

$$= \min[6.42, \max(6.4451, 4.5)]$$

$$= 6.4200 \text{ mm}$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N7-50-Temp Gaug Nozl: 19 3:11pm Jul 28,2023

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$\begin{aligned}
 &= \max(t_a, t_b) \\
 &= \max(3.2827, 6.42) \\
 &= 6.4200 \text{ mm}
 \end{aligned}$$

Available Nozzle Neck Thickness = $0.875 * 8.738 = 7.645 \text{ mm}$ --> OK**Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:****Nozzle Neck to Flange Weld, min(Curve:C, Curve:B)**Govrn. thk, $t_g = 7.645$, $t_r = 0.09$, $c = 3.0 \text{ mm}$, $E* = 1.0$ Thickness Ratio = $t_r * E* / (t_g - c) = 0.019$, Temp. Reduction = 78°C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29°C
Min Metal Temp. at Required thickness (UCS 66.1)	-104°C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:C, Curve:D)Govrn. thk, $t_g = 7.645$, $t_r = 0.09$, $c = 3.0 \text{ mm}$, $E* = 1.0$ Thickness Ratio = $t_r * E* / (t_g - c) = 0.019$, Temp. Reduction = 78°C

Min Metal Temp. w/o impact per UCS-66, Curve C	-48°C
Min Metal Temp. at Required thickness (UCS 66.1)	-104°C

Gov. MDMT of the nozzle to shell joint welded assembly : -104°C **ANSI Flange MDMT including Temperature reduction per UCS-66.1:**

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18°C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b)	-104°C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

$$\text{Design Pressure/Ambient Rating} = 3.60/52.11 = 0.069$$

Weld Size Calculations, Description: N7-50-Temp GaugIntermediate Calc. for nozzle/shell Welds T_{min} 5.7376 mm **Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	$4.0163 = 0.7 * t_{min.}$	$7.0700 = 0.7 * W_o \text{ mm}$

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 9 kgf/cm^2

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 0.3639 mm The Cut Length for this Nozzle is, Drop + Ho + H + T : 162.3640 mm

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N1-600-Vapour O Nozl: 20 3:11pm Jul 28,2023

Input, Nozzle Desc: N1-600-Vapour Outlet

From: 30

Pressure for Reinforcement Calculations	P	3.500	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Cylindrical Shell	D	2500.00	mm
Design Length of Section	L	2480.0002	mm
Shell Finished (Minimum) Thickness	t	12.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		268.63	cm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material [Normalized]		SA-516 70	
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	1310.00	kgf/cm ²
Allowable Stress At Ambient	Sna	1406.10	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		90.00	deg
Diameter		24.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.0000	mm
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	1310.00	kgf/cm ²
Pad Allowable Stress At Ambient	Spa	1406.10	kgf/cm ²
Diameter of Pad along vessel surface	Dp	1209.6000	mm
Thickness of Pad	te	12.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm
Reinforcing Pad Width		300.0000	mm
Flange Class		300	
Flange Grade		GR 1.1	

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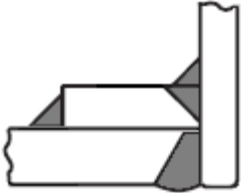
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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N1-600-Vapour O Nozl: 20 3:11pm Jul 28,2023

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: N1-600-Vapour Outlet

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	24.000 in.
Actual Thickness Used in Calculation	0.472 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]

$$= P \cdot R / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)}$$

$$= 3.5 \cdot 1253.0 / (1310 \cdot 1.0 - 0.6 \cdot 3.5)$$

$$= 3.3531 \text{ mm}$$

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]

$$= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)}$$

$$= 3.5 \cdot 304.8 / (1310 \cdot 1.0 + 0.4 \cdot 3.5)$$

$$= 0.8135 \text{ mm}$$

Required Nozzle thickness under External Pressure per UG-28 : 1.0872 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	1183.2001 mm
Parallel to Vessel Wall, opening length	d	591.6000 mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		22.5000 mm

The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 1310.0 / 1310.0)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr2]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 1310.0 / 1310.0)$$

$$= 1.000$$

Weld Strength Reduction Factor [fr4]:

$$= \min(1, S_p / S_v)$$

$$= \min(1, 1310.0 / 1310.0)$$

$$= 1.000$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N1-600-Vapour O Nozl: 20 3:11pm Jul 28,2023

Weld Strength Reduction Factor [fr3]:

$$= \min(\text{fr2}, \text{fr4})$$

$$= \min(1., 1.)$$

$$= 1.000$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	19.837	23.776	NA
Area in Shell	A1	0.000	0.000	NA
Area in Nozzle Wall	A2	0.000	0.000	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		1.000	1.000	NA
Area in Element	A5	68.831	68.831	NA
TOTAL AREA AVAILABLE	Atot	69.831	69.831	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	799.4042	12.0000 mm
Based on given Pad Diameter:	1209.6000	3.9708 mm
Based on Shell or Nozzle Thickness:	799.4042	12.0000 mm

Area Required [A]:

$$= 0.5(d * tr * F + 2 * tn * tr * F(1 - fr1)) \text{ per UG-37(d)}$$

$$= 0.5(591.6 * 8.038 * 1 + 2 * 9.0 * 8.038 * 1(1 - 1.))$$

$$= 23.776 \text{ cm}^2$$

The area in the shell has not been calculated by user request.

The area in the nozzle wall has not been calculated by user request.

Area 2wp has not been Calculated by User Request.

Area Available in Welds [A41 + A42 + A43]:

$$= W_o^2 * fr3 + (W_i - can / 0.707)^2 * fr2 + W_p^2 * fr4$$

$$= 10.0^2 * 1. + (0.0)^2 * 1. + 0.0^2 * 1.$$

$$= 1.000 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(D_p, DL) - (\text{Nozzle OD})) * (\min(t_p, t_{lwp}, t_e)) * fr4$$

$$= (1183.2001 - 609.6) * 12.0 * 1.$$

$$= 68.831 \text{ cm}^2$$

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures ta = 4.0872 mm

Wall Thickness per UG16(b), tr16b = 4.5000 mm

Wall Thickness, shell/head, internal pressure trb1 = 6.3531 mm

Wall Thickness tb1 = max(trb1, tr16b) = 6.3531 mm

Wall Thickness, shell/head, external pressure trb2 = 4.0092 mm

Wall Thickness tb2 = max(trb2, tr16b) = 4.5000 mm

Wall Thickness per table UG-45 tb3 = 11.3312 mm

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb3, \max(tb1, tb2)]$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N1-600-Vapour O Nozl: 20 3:11pm Jul 28,2023

$$= \min[11.331, \max(6.3531, 4.5)]$$

$$= 6.3531 \text{ mm}$$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$= \max(t_a, t_b)$$

$$= \max(4.0872, 6.3531)$$

$$= 6.3531 \text{ mm}$$

Available Nozzle Neck Thickness = 12.0000 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:**Nozzle Neck to Flange Weld, min(Curve:D, Curve:B)**

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^*/(tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-23 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: D

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^*/(tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^*/(tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 12.0, tr = 3.123, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^*/(tg - c) = 0.347$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: D

Govrn. thk, tg = 12.0, tr = 3.123, c = 3.0 mm, E* = 1.0

Thickness Ratio = $tr * E^*/(tg - c) = 0.347$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Gov. MDMT of the Nozzle	: -104 °C
Gov. MDMT of the Reinforcement Pad	: -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly	: -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N1-600-Vapour O Nozl: 20 3:11pm Jul 28,2023

Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 3.50/52.11 = 0.067

Weld Size Calculations, Description: N1-600-Vapour O

Intermediate Calc. for nozzle/shell Welds	Tmin	9.0000	mm
Intermediate Calc. for pad/shell Welds	TminPad	9.0000	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	7.0700 = 0.7 * Wo mm
Pad Weld	4.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) S_v)$$

$$= \max(0, (23.7763 - 0.0 + 2 * 9.0 * 1. * (1.0 * 9.0 - 8.038)) 1310)$$

$$= 31374.02 \text{ kgf}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W1 - Can / .707)^2 * f_{r2}) * S_v$$

$$= (0.0 + 68.8314 + 1. - 0.0 * 1.) * 1310$$

$$= 91479.80 \text{ kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (0.0 + 0.0 + 1. + (1.62)) * 1310$$

$$= 3432.19 \text{ kgf}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (0.0 + 0.0 + 1. + 68.8314 + (1.62)) * 1310$$

$$= 93602.00 \text{ kgf}$$
Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * D_{lo} * W_o * 0.49 * S_{nw}$$

$$= (3.1416/2.0) * 609.6 * 10.0 * 0.49 * 1310$$

$$= 61466. \text{ kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * S_{EW}$$

$$= (3.1416/2.0) * 1209.6 * 8.0 * 0.49 * 1310$$

$$= 97570. \text{ kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - Can) * 0.7 * S_n$$

$$= (3.1416 * 300.3) * (12.0 - 3.0) * 0.7 * 1310$$

$$= 77860. \text{ kgf}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

$$= (3.1416/2) * 609.6 * 12.0 * 0.74 * 1310$$

$$= 111391. \text{ kgf}$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N1-600-Vapour O Nozl: 20 3:11pm Jul 28,2023

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (T - c_{as}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 609.6 * (12.0 - 3.0) * 0.74 * 1310 \\
 &= 83544. \text{ kgf}
 \end{aligned}$$

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:

$$= (SPEW + SNW) = (97570 + 77860) = 175431 \text{ kgf}$$

Failure Path [Path 2-2]:

$$\begin{aligned}
 &= (S_{onw} + T_{pgw} + T_{ngw} + S_{inw}) \\
 &= (61466 + 111391 + 83544 + 0) = 256400 \text{ kgf}
 \end{aligned}$$

Failure Path [Path 3-3]:

$$\begin{aligned}
 &= (S_{pew} + T_{ngw} + S_{inw}) \\
 &= (97570 + 83544 + 0) = 181114 \text{ kgf}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 175430 kgf, must exceed W = 31374 kgf	or W1 = 91479 kgf
Path 2-2 = 256399 kgf, must exceed W = 31374 kgf	or W2 = 3432 kgf
Path 3-3 = 181114 kgf, must exceed W = 31374 kgf	or W3 = 93602 kgf

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 9 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure: 1 kgf/cm²

The Drop for this Nozzle is : 37.7306 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 199.7307 mm

Percent Elongation Calculations:% Elongation per Table UG-79-1 (50*t_{nom}/R_f*(1-R_f/R_o)) 2.008 %

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DECOKING DRUM

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N4-100-Water Ou Nozl: 21 3:11pm Jul 28,2023

Input, Nozzle Desc: N4-100-Water Outlet From: 40

Pressure for Reinforcement Calculations	P	3.500	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Cylindrical Shell	D	2500.00	mm
Design Length of Section	L	1258.3334	mm
Shell Finished (Minimum) Thickness	t	12.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		498.64	cm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	1177.10	kgf/cm ²
Allowable Stress At Ambient	Sna	1202.20	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		4.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness		80	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	1310.01	kgf/cm ²
Pad Allowable Stress At Ambient	Spa	1406.14	kgf/cm ²
Diameter of Pad along vessel surface	Dp	224.3000	mm
Thickness of Pad	te	12.0000	mm
Weld leg size between Pad and Shell	Wp	10.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm
Reinforcing Pad Width		55.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

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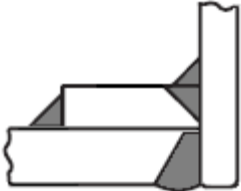
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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N4-100-Water Ou Nozl: 21 3:11pm Jul 28,2023

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: N4-100-Water Outlet

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	4.500 in.
Actual Thickness Used in Calculation	0.337 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]

$$= P \cdot R / (S_v \cdot E - 0.6 \cdot P) \text{ per UG-27 (c) (1)}$$

$$= 3.5 \cdot 1253.0 / (1310 \cdot 1.0 - 0.6 \cdot 3.5)$$

$$= 3.3531 \text{ mm}$$

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]

$$= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)}$$

$$= 3.5 \cdot 57.15 / (1177 \cdot 1.0 + 0.4 \cdot 3.5)$$

$$= 0.1697 \text{ mm}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.4104 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	206.3608 mm
Parallel to Vessel Wall, opening length	d	103.1804 mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		22.5000 mm

The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 1177.1 / 1310.0)$$

$$= 0.899$$

Weld Strength Reduction Factor [fr2]:

$$= \min(1, S_n / S_v)$$

$$= \min(1, 1177.1 / 1310.0)$$

$$= 0.899$$

Weld Strength Reduction Factor [fr4]:

$$= \min(1, S_p / S_v)$$

$$= \min(1, 1310.0 / 1310.0)$$

$$= 1.000$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N4-100-Water Ou Nozl: 21 3:11pm Jul 28,2023

Weld Strength Reduction Factor [fr3]:

$$\begin{aligned}
 &= \min(\text{fr2}, \text{fr4}) \\
 &= \min(0.899, 1.) \\
 &= 0.899
 \end{aligned}$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	3.498	3.166	NA
Area in Shell	A1	0.000	0.000	NA
Area in Nozzle Wall	A2	0.000	0.000	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.899	0.899	NA
Area in Element	A5	11.047	11.047	NA
TOTAL AREA AVAILABLE	Atot	11.946	11.946	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	135.9582	12.0000 mm
Based on given Pad Diameter:	224.3000	2.8231 mm
Based on Shell or Nozzle Thickness:	144.6627	8.5598 mm

Area Required [A]:

$$\begin{aligned}
 &= (d * \text{tr} * F + 2 * \text{tn} * \text{tr} * F * (1 - \text{fr1})) \text{ UG-37(c)} \\
 &= (103.1804 * 3.3531 * 1.0 + 2 * 5.5598 * 3.3531 * 1.0 * (1 - 0.9)) \\
 &= 3.498 \text{ cm}^2
 \end{aligned}$$

The area in the shell has not been calculated by user request.

The area in the nozzle wall has not been calculated by user request.

Area 2wp has not been Calculated by User Request.

Area Available in Welds [A41 + A42 + A43]:

$$\begin{aligned}
 &= W_o^2 * \text{fr3} + (W_i - \text{can} / 0.707)^2 * \text{fr2} + W_p^2 * \text{fr4} \\
 &= 10.0^2 * 0.9 + (0.0)^2 * 0.9 + 0.0^2 * 1. \\
 &= 0.899 \text{ cm}^2
 \end{aligned}$$

Area Available in Element [A5]:

$$\begin{aligned}
 &= (\min(D_p, D_L) - (\text{Nozzle OD})) * (\min(t_p, t_{lwp}, t_e)) * \text{fr4} \\
 &= (206.3608 - 114.3) * 12.0 * 1. \\
 &= 11.047 \text{ cm}^2
 \end{aligned}$$

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.4104 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 6.3531 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 6.3531 mm
Wall Thickness, shell/head, external pressure	trb2 = 4.0092 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 8.2578 mm

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb3, \max(tb1, tb2)]$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N4-100-Water Ou Nozl: 21 3:11pm Jul 28,2023

$$= \min[8.258, \max(6.3531, 4.5)]$$

$$= 6.3531 \text{ mm}$$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$= \max(t_a, t_b)$$

$$= \max(3.4104, 6.3531)$$

$$= 6.3531 \text{ mm}$$

Available Nozzle Neck Thickness = $0.875 * 8.560 = 7.490 \text{ mm} \rightarrow \text{OK}$ **Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:****Nozzle Neck to Flange Weld, min(Curve:C, Curve:B)**Govrn. thk, tg = 7.49, tr = 0.166, c = 3.0 mm, $E^* = 1.0$ Thickness Ratio = $tr * E^* / (tg - c) = 0.037$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: CGovrn. thk, tg = 7.49, tr = 0.166, c = 3.0 mm, $E^* = 1.0$ Thickness Ratio = $tr * E^* / (tg - c) = 0.037$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: BGovrn. thk, tg = 7.49, tr = 0.166, c = 3.0 mm, $E^* = 1.0$ Thickness Ratio = $tr * E^* / (tg - c) = 0.037$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Shell to Pad Weld Junction at Pad OD, min(Curve:B, Curve:D)Govrn. thk, tg = 12.0, tr = 3.123, c = 3.0 mm, $E^* = 1.0$ Thickness Ratio = $tr * E^* / (tg - c) = 0.347$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-23 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:C, Curve:D)Govrn. thk, tg = 7.49, tr = 0.166, c = 3.0 mm, $E^* = 1.0$ Thickness Ratio = $tr * E^* / (tg - c) = 0.037$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Gov. MDMT of the Nozzle	: -104 °C
Gov. MDMT of the Reinforcement Pad	: -104 °C
Gov. MDMT of the nozzle to shell joint welded assembly	: -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N4-100-Water Ou Nozl: 21 3:11pm Jul 28,2023

Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = 3.50/19.99 = 0.175

Weld Size Calculations, Description: N4-100-Water Ou

Intermediate Calc. for nozzle/shell Welds	Tmin	5.5598	mm
Intermediate Calc. for pad/shell Welds	TminPad	9.0000	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.8919 = 0.7 * tmin.	7.0700 = 0.7 * Wo mm
Pad Weld	4.5000 = 0.5*TminPad	7.0700 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * t_n * f_{r1} * (E1 * t - t_r)) S_v)$$

$$= \max(0, (3.4975 - 0.0 + 2 * 5.5598 * 0.8985 * (1.0 * 9.0 - 3.3531)) 1310)$$

$$= 5320.91 \text{ kgf}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2 + A5 + A4 - (W_i - Can / .707)^2 * f_{r2}) * S_v$$

$$= (0.0 + 11.0473 + 0.8985 - 0.0 * 0.9) * 1310$$

$$= 15649.15 \text{ kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * t_n * t * f_{r1})) * S_v$$

$$= (0.0 + 0.0 + 0.8985 + (0.8992)) * 1310$$

$$= 2355.10 \text{ kgf}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * t_n * t * f_{r1})) * S$$

$$= (0.0 + 0.0 + 0.8985 + 11.0473 + (0.8992)) * 1310$$

$$= 16827.14 \text{ kgf}$$
Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * D_{lo} * W_o * 0.49 * S_{nw}$$

$$= (3.1416/2.0) * 114.3 * 10.0 * 0.49 * 1177$$

$$= 10356. \text{ kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * S_{EW}$$

$$= (3.1416/2.0) * 224.3 * 10.0 * 0.49 * 1310$$

$$= 22616. \text{ kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * (D_{lr} + D_{lo}) / 4) * (Thk - Can) * 0.7 * S_n$$

$$= (3.1416 * 54.3701) * (8.5598 - 3.0) * 0.7 * 1177$$

$$= 7825. \text{ kgf}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * D_{lo} * W_{gpn} * 0.74 * S_{eg}$$

$$= (3.1416/2) * 114.3 * 12.0 * 0.74 * 1310$$

$$= 20886. \text{ kgf}$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N4-100-Water Ou Nozl: 21 3:11pm Jul 28,2023

Tension, Shell Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * D_{lo} * (T - c_{as}) * 0.74 * S_{ng} \\
 &= (3.1416/2.0) * 114.3 * (12.0 - 3.0) * 0.74 * 1310 \\
 &= 15664. \text{ kgf}
 \end{aligned}$$

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:

$$= (SPEW + SNW) = (22616 + 7825) = 30441 \text{ kgf}$$

Failure Path [Path 2-2]:

$$\begin{aligned}
 &= (S_{onw} + T_{pgw} + T_{ngw} + S_{inw}) \\
 &= (10356 + 20886 + 15664 + 0) = 46906 \text{ kgf}
 \end{aligned}$$

Failure Path [Path 3-3]:

$$\begin{aligned}
 &= (S_{pew} + T_{ngw} + S_{inw}) \\
 &= (22616 + 15664 + 0) = 38281 \text{ kgf}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 30441	kgf, must exceed W = 5320 kgf	or W1 = 15649 kgf
Path 2-2 = 46905	kgf, must exceed W = 5320 kgf	or W2 = 2355 kgf
Path 3-3 = 38280	kgf, must exceed W = 5320 kgf	or W3 = 16827 kgf

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 5 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure: 1 kgf/cm²

The Drop for this Nozzle is : 1.3071 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 163.3071 mm

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DECOKING DRUM

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N3-600-Steam Ou Nozl: 22 3:11pm Jul 28,2023

Input, Nozzle Desc: N3-600-Steam Outlet From: 50

Pressure for Reinforcement Calculations	P	3.500	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Elliptical Head	D	2500.00	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	10.0000	mm
Head Internal Corrosion Allowance	c	3.0000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	0.0000	mm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material [Normalized]		SA-516 70	
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	1310.00	kgf/cm ²
Allowable Stress At Ambient	Sna	1406.10	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		24.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.0000	mm
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material [Normalized]		SA-516 70	
Pad Allowable Stress at Temperature	Sp	1310.00	kgf/cm ²
Pad Allowable Stress At Ambient	Spa	1406.10	kgf/cm ²
Diameter of Pad along vessel surface	Dp	1209.6000	mm
Thickness of Pad	te	12.0000	mm
Weld leg size between Pad and Shell	Wp	8.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	12.0000	mm
Reinforcing Pad Width		300.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

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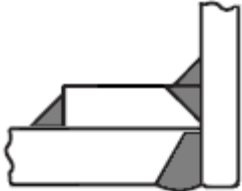
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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N3-600-Steam Ou Nozl: 22 3:11pm Jul 28,2023

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: N3-600-Steam Outlet

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	24.000 in.
Actual Thickness Used in Calculation	0.472 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, tr [Int. Press]
 $= P \cdot D \cdot K_1 / (2 \cdot S_v \cdot E - 0.2 \cdot P)$ per Appendix 1-4 (c)
 $= 0.9 \cdot 3.5 \cdot 2506.0 / (2 \cdot 1310.01 \cdot 1.0 - 0.2 \cdot 3.5)$
 $= 3.0068 \text{ mm}$

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
 $= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P)$ per Appendix 1-1 (a) (1)
 $= 3.5 \cdot 304.8 / (1310 \cdot 1.0 + 0.4 \cdot 3.5)$
 $= 0.8135 \text{ mm}$

Required Nozzle thickness under External Pressure per UG-28 : 1.0872 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	1183.2001	mm
Parallel to Vessel Wall, opening length	d	591.6000	mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp		17.5000	mm

The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

$= \min(1, S_n / S_v)$
 $= \min(1, 1310.0 / 1310.0)$
 $= 1.000$

Weld Strength Reduction Factor [fr2]:

$= \min(1, S_n / S_v)$
 $= \min(1, 1310.0 / 1310.0)$
 $= 1.000$

Weld Strength Reduction Factor [fr4]:

$= \min(1, S_p / S_v)$
 $= \min(1, 1310.0 / 1310.0)$
 $= 1.000$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N3-600-Steam Ou Nozl: 22 3:11pm Jul 28,2023

Weld Strength Reduction Factor [fr3]:

$$= \min(\text{fr2}, \text{fr4})$$

$$= \min(1., 1.)$$

$$= 1.000$$

Results of Nozzle Reinforcement Area Calculations: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	17.788	19.307	NA
Area in Shell	A1	0.000	0.000	NA
Area in Nozzle Wall	A2	0.000	0.000	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds A41+A42+A43		0.797	0.797	NA
Area in Element	A5	68.831	68.831	NA
TOTAL AREA AVAILABLE	Atot	69.629	69.629	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness
Based on given Pad Thickness:	763.8457	12.0000 mm
Based on given Pad Diameter:	1209.6000	3.2269 mm
Based on Shell or Nozzle Thickness:	794.6948	10.0000 mm

Area Required [A]:

$$= 0.5(d * \text{tr} * F + 2 * \text{tn} * \text{tr} * F(1 - \text{fr1})) \text{ per UG-37(d)}$$

$$= 0.5(591.6 * 6.527 * 1 + 2 * 9.0 * 6.527 * 1(1 - 1.))$$

$$= 19.307 \text{ cm}^2$$

The area in the shell has not been calculated by user request.

The area in the nozzle wall has not been calculated by user request.

Area 2wp has not been Calculated by User Request.

Area Available in Welds [A41 + A42 + A43]:

$$= (W_o^2 - \text{Ar Lost}) * \text{Fr3} + ((W_i - \text{can} / 0.707)^2 - \text{Ar Lost}) * \text{fr2} + W_p^2 * \text{fr4}$$

$$= (0.7975) * 1. + (0.0) * 1. + 0.0^2 * 1.$$

$$= 0.797 \text{ cm}^2$$

Area Available in Element [A5]:

$$= (\min(D_p, D_L) - (\text{Nozzle OD})) * (\min(t_p, t_{lwp}, t_e)) * \text{fr4}$$

$$= (1183.2001 - 609.6) * 12.0 * 1.$$

$$= 68.831 \text{ cm}^2$$

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 4.0872 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 6.3379 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 6.3379 mm
Wall Thickness, shell/head, external pressure	trb2 = 4.0056 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 11.3312 mm

Determine Nozzle Thickness candidate [tb]:

$$= \min[tb3, \max(tb1, tb2)]$$

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FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N3-600-Steam Ou Nozl: 22 3:11pm Jul 28,2023

$$= \min[11.331, \max(6.3379, 4.5)]$$

$$= 6.3379 \text{ mm}$$

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

$$= \max(t_a, t_b)$$

$$= \max(4.0872, 6.3379)$$

$$= 6.3379 \text{ mm}$$

Available Nozzle Neck Thickness = 12.0000 mm --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:**Nozzle Neck to Flange Weld, min(Curve:D, Curve:B)**

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, $E^* = 1.0$
 Thickness Ratio = $tr * E^* / (tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-23 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for the Nozzle, Curve: D

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, $E^* = 1.0$
 Thickness Ratio = $tr * E^* / (tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: D

Govrn. thk, tg = 12.0, tr = 0.758, c = 3.0 mm, $E^* = 1.0$
 Thickness Ratio = $tr * E^* / (tg - c) = 0.084$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Shell to Pad Weld Junction at Pad OD, Curve: D

Govrn. thk, tg = 10.0, tr = 2.801, c = 3.0 mm, $E^* = 1.0$
 Thickness Ratio = $tr * E^* / (tg - c) = 0.4$, Temp. Reduction = 51 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
--	--------

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: D

Govrn. thk, tg = 10.0, tr = 2.801, c = 3.0 mm, $E^* = 1.0$
 Thickness Ratio = $tr * E^* / (tg - c) = 0.4$, Temp. Reduction = 51 °C

Min Metal Temp. w/o impact per UCS-66, Curve D	-48 °C
--	--------

Gov. MDMT of the Nozzle	:	-48 °C
Gov. MDMT of the Reinforcement Pad	:	-48 °C
Gov. MDMT of the nozzle to shell joint welded assembly	:	-48 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)	-18 °C
Flange MDMT with Temp reduction per UCS-66(b) (1) (-b)	-104 °C

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N3-600-Steam Ou Nozl: 22 3:11pm Jul 28,2023

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

$$\text{Design Pressure/Ambient Rating} = 3.50/19.99 = 0.175$$

Weld Size Calculations, Description: N3-600-Steam Ou

Intermediate Calc. for nozzle/shell Welds	Tmin	9.0000	mm
Intermediate Calc. for pad/shell Welds	TminPad	9.0000	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	7.0700 = 0.7 * Wo mm
Pad Weld	4.5000 = 0.5*TminPad	5.6560 = 0.7 * Wp mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

$$= \max(0, (A - A1 + 2 * tn * fr1 * (E1 * t - tr)) * Sv)$$

$$= \max(0, (19.3068 - 0.0 + 2 * 9.0 * 1. * (1.0 * 7.0 - 6.527) * 1310))$$

$$= 25403.65 \text{ kgf}$$

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

$$= (A2 + A5 + A4 - (Wi - Can / .707)^2 * fr2) * Sv$$

$$= (0.0 + 68.8314 + 0.7975 - 0.0 * 1.0) * 1310$$

$$= 91214.52 \text{ kgf}$$

Weld Load [W2]:

$$= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv$$

$$= (0.0 + 0.0 + 1.0 + (1.26)) * 1310$$

$$= 2960.60 \text{ kgf}$$

Weld Load [W3]:

$$= (A2 + A3 + A4 + A5 + (2 * tn * t * fr1)) * S$$

$$= (0.0 + 0.0 + 0.7975 + 68.8314 + (1.26)) * 1310$$

$$= 92865.12 \text{ kgf}$$

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

$$= (\pi/2) * Dlo * Wo * 0.49 * Snw$$

$$= (3.1416/2.0) * 609.6 * 10.0 * 0.49 * 1310$$

$$= 61466. \text{ kgf}$$

Shear, Pad Element Weld [Spew]:

$$= (\pi/2) * DP * WP * 0.49 * SEW$$

$$= (3.1416/2.0) * 1209.6 * 8.0 * 0.49 * 1310$$

$$= 97570. \text{ kgf}$$

Shear, Nozzle Wall [Snw]:

$$= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn$$

$$= (3.1416 * 300.3) * (12.0 - 3.0) * 0.7 * 1310$$

$$= 77860. \text{ kgf}$$

Tension, Pad Groove Weld [Tpgw]:

$$= (\pi/2) * Dlo * Wgpn * 0.74 * Seg$$

$$= (3.1416/2.0) * 609.6 * 12.0 * 0.74 * 1310$$

$$= 111391. \text{ kgf}$$

Tension, Shell Groove Weld [Tngw]:

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Nozzle Calcs.: N3-600-Steam Ou Nozl: 22 3:11pm Jul 28,2023

$$\begin{aligned}
 &= (\pi/2) * Dlo * (T - cas) * 0.74 * Sng \\
 &= (3.1416/2.0) * 609.6 * (10.0 - 3.0) * 0.74 * 1310 \\
 &= 64978. \text{ kgf}
 \end{aligned}$$

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:

$$= (SPEW + SNW) = (97570 + 77860) = 175431 \text{ kgf}$$

Failure Path [Path 2-2]:

$$\begin{aligned}
 &= (Sonw + Tpgw + Tngw + Sinw) \\
 &= (61466 + 111391 + 64978 + 0) = 237835 \text{ kgf}
 \end{aligned}$$

Failure Path [Path 3-3]:

$$\begin{aligned}
 &= (Spew + Tngw + Sinw) \\
 &= (97570 + 64978 + 0) = 162549 \text{ kgf}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 175430 kgf, must exceed W = 25403 kgf or W1 = 91214 kgf
 Path 2-2 = 237834 kgf, must exceed W = 25403 kgf or W2 = 2960 kgf
 Path 3-3 = 162548 kgf, must exceed W = 25403 kgf or W3 = 92865 kgf

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 7 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure: 1 kgf/cm²

The Drop for this Nozzle is : 20.6666 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 180.6665 mm

Percent Elongation Calculations:

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 2.008 %

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DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N6-50-PG Nozl: 23 3:11pm Jul 28,2023

Input, Nozzle Desc: N6-50-PG**From: 50**

Pressure for Reinforcement Calculations	P	3.500	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Elliptical Head	D	2500.00	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	10.0000	mm
Head Internal Corrosion Allowance	c	3.0000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	979.9999	mm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	1177.10	kgf/cm ²
Allowable Stress At Ambient	Sna	1202.20	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		300	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

(ITEM NO.412-H-1001-V01)

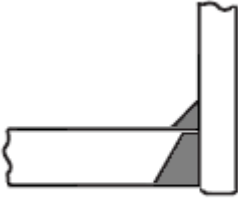
Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N6-50-PG Nozl: 23 3:11pm Jul 28,2023

**Insert/Set-in Nozzle No Pad, no Inside projection**Note : Checking Nozzle in the Meridional direction.**Reinforcement CALCULATION, Description: N6-50-PG**

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	2.375 in.
Actual Thickness Used in Calculation	0.344 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, tr [Int. Press]

$$= P \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot P) \text{ per Appendix 1-4 (c)}$$

$$= 3.5 \cdot 2506.0 \cdot 0.997 / (2 \cdot 1310.01 \cdot 1.0 - 0.2 \cdot 3.5)$$

$$= 3.3379 \text{ mm}$$

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]

$$= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)}$$

$$= 3.5 \cdot 30.1625 / (1177 \cdot 1.0 + 0.4 \cdot 3.5)$$

$$= 0.0896 \text{ mm}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.2827 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	115.3658 mm
Parallel to Vessel Wall, opening length	d	57.6829 mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.3440 mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N6-50-PG

This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:**Nozzle Neck to Flange Weld, min(Curve:C, Curve:B)**

Govrn. thk, tg = 7.645, tr = 0.088, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.019, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:C, Curve:D)

(ITEM NO.412-H-1001-V01)

Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N6-50-PG Nozl: 23 3:11pm Jul 28,2023

Govrn. thk, $t_g = 7.645$, $t_r = 0.088$, $c = 3.0$ mm, $E^* = 1.0$ Thickness Ratio = $t_r * E^* / (t_g - c) = 0.019$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C -48 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c) -18 °C

Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $3.50/52.11 = 0.067$ Weld Size Calculations. Description: N6-50-PGIntermediate Calc. for nozzle/shell Welds $T_{min} = 5.7376$ mm**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	$4.0163 = 0.7 * t_{min}$	$7.0700 = 0.7 * W_o$ mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 7 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Note : Checking Nozzle in the Latitudinal direction.**Reinforcement CALCULATION, Description: N6-50-PG**

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in.

Actual Thickness Used in Calculation 0.344 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, t_r [Int. Press] $= P * D * K / (2 * S_v * E - 0.2 * P)$ per Appendix 1-4(c) $= 3.5 * 2506.0 * 0.997 / (2 * 1310.01 * 1.0 - 0.2 * 3.5)$ $= 3.3379$ mmReqd thk per UG-37(a) of Nozzle Wall, t_{rn} [Int. Press] $= P * R_o / (S_n * E + 0.4 * P)$ per Appendix 1-1 (a) (1) $= 3.5 * 30.1625 / (1177 * 1.0 + 0.4 * 3.5)$ $= 0.0896$ mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2827 mm

UG-40, Limits of Reinforcement : [Internal Pressure]Parallel to Vessel Wall (Diameter Limit) $D_1 = 97.6996$ mmParallel to Vessel Wall, opening length $d = 48.8498$ mmNormal to Vessel Wall (Thickness Limit), no pad $T_{lnp} = 14.3440$ mm

(ITEM NO.412-H-1001-V01)

Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N6-50-PG Nozl: 23 3:11pm Jul 28,2023

*Taking a UG-36(c)(3)(a) exemption for nozzle: N6-50-PG**This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.***UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]**

Wall Thickness for Internal/External pressures	ta = 3.2827 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 6.3379 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 6.3379 mm
Wall Thickness, shell/head, external pressure	trb2 = 4.0056 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:

= min[tb3, max(tb1,tb2)]
 = min[6.42, max(6.3379, 4.5)]
 = 6.3379 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

= max(ta, tb)
 = max(3.2827, 6.3379)
 = 6.3379 mm

Available Nozzle Neck Thickness = $0.875 \times 8.738 = 7.645$ mm --> OKWeld Size Calculations. Description: N6-50-PG

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.0163 = 0.7 \times t_{min}$	$7.0700 = 0.7 \times W_o$ mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 7 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 14.8084 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 175.9027 mm

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Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N8-50-SPARE Nozl: 24 3:11pm Jul 28,2023

Input, Nozzle Desc: N8-50-SPARE

From: 50

Pressure for Reinforcement Calculations	P	3.500	kgf/cm ²
Temperature for Internal Pressure	Temp	350	°C
Design External Pressure	Pext	1.05	kgf/cm ²
Temperature for External Pressure	Tempex	150	°C
Parent Material [Normalized]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	1310.01	kgf/cm ²
Parent Allowable Stress At Ambient	Sva	1406.14	kgf/cm ²
Inside Diameter of Elliptical Head	D	2500.00	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	10.0000	mm
Head Internal Corrosion Allowance	c	3.0000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	979.9999	mm
User Entered Minimum Design Metal Temperature		-0.70	°C

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	1177.10	kgf/cm ²
Allowable Stress At Ambient	Sna	1202.20	kgf/cm ²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		180.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	10.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

(ITEM NO.412-H-1001-V01)

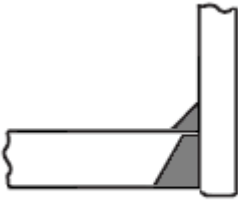
Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N8-50-SPARE Nozl: 24 3:11pm Jul 28,2023

**Insert/Set-in Nozzle No Pad, no Inside projection**Note : Checking Nozzle in the Meridional direction.**Reinforcement CALCULATION, Description: N8-50-SPARE**

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	2.375 in.
Actual Thickness Used in Calculation	0.344 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, tr [Int. Press]

$$= P \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot P) \text{ per Appendix 1-4 (c)}$$

$$= 3.5 \cdot 2506.0 \cdot 0.997 / (2 \cdot 1310.01 \cdot 1.0 - 0.2 \cdot 3.5)$$

$$= 3.3379 \text{ mm}$$

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]

$$= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \text{ per Appendix 1-1 (a) (1)}$$

$$= 3.5 \cdot 30.1625 / (1177 \cdot 1.0 + 0.4 \cdot 3.5)$$

$$= 0.0896 \text{ mm}$$

Required Nozzle thickness under External Pressure per UG-28 : 0.2827 mm

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	D1	115.3658 mm
Parallel to Vessel Wall, opening length	d	57.6829 mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.3440 mm

Taking a UG-36(c)(3)(a) exemption for nozzle: N8-50-SPARE

This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:**Nozzle Neck to Flange Weld, min(Curve:C, Curve:B)**

Govrn. thk, tg = 7.645, tr = 0.088, c = 3.0 mm, E* = 1.0

Thickness Ratio = tr * E*/(tg - c) = 0.019, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), min(Curve:C, Curve:D)

(ITEM NO.412-H-1001-V01)

Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N8-50-SPARE Nozl: 24 3:11pm Jul 28,2023

Govrn. thk, $t_g = 7.645$, $t_r = 0.088$, $c = 3.0$ mm, $E^* = 1.0$ Thickness Ratio = $t_r * E^* / (t_g - c) = 0.019$, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve C -48 °C

Min Metal Temp. at Required thickness (UCS 66.1) -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c) -18 °C

Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

Design Pressure/Ambient Rating = $3.50/19.99 = 0.175$ Weld Size Calculations. Description: N8-50-SPAREIntermediate Calc. for nozzle/shell Welds T_{min} 5.7376 mm**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	$4.0163 = 0.7 * t_{min}$	$7.0700 = 0.7 * W_o$ mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 7 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Note : Checking Nozzle in the Latitudinal direction.**Reinforcement CALCULATION, Description: N8-50-SPARE**

ASME Code, Section VIII, Div. 1, 2021, UG-37 to UG-45

Actual Outside Diameter Used in Calculation 2.375 in.

Actual Thickness Used in Calculation 0.344 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, t_r [Int. Press] $= P * D * K / (2 * S_v * E - 0.2 * P)$ per Appendix 1-4(c) $= 3.5 * 2506.0 * 0.997 / (2 * 1310.01 * 1.0 - 0.2 * 3.5)$ $= 3.3379$ mmReqd thk per UG-37(a) of Nozzle Wall, t_{rn} [Int. Press] $= P * R_o / (S_n * E + 0.4 * P)$ per Appendix 1-1 (a) (1) $= 3.5 * 30.1625 / (1177 * 1.0 + 0.4 * 3.5)$ $= 0.0896$ mm

Required Nozzle thickness under External Pressure per UG-28 : 0.2827 mm

UG-40, Limits of Reinforcement : [Internal Pressure]Parallel to Vessel Wall (Diameter Limit) D_l 97.6996 mmParallel to Vessel Wall, opening length d 48.8498 mmNormal to Vessel Wall (Thickness Limit), no pad T_{lnp} 14.3440 mm

(ITEM NO.412-H-1001-V01)

Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Nozzle Calcs.: N8-50-SPARE Nozl: 24 3:11pm Jul 28,2023

*Taking a UG-36(c)(3)(a) exemption for nozzle: N8-50-SPARE
This calculation is valid for nozzles that meet all the requirements of
paragraph UG-36. Please check the Code carefully, especially for nozzles
that are not isolated or do not meet Code spacing requirements. To force
the computation of areas for small nozzles go to Tools->Configuration
and check the box to force the UG-37 small nozzle area calculation.*

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness for Internal/External pressures	ta = 3.2827 mm
Wall Thickness per UG16(b),	tr16b = 4.5000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 6.3379 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 6.3379 mm
Wall Thickness, shell/head, external pressure	trb2 = 4.0056 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.5000 mm
Wall Thickness per table UG-45	tb3 = 6.4200 mm

Determine Nozzle Thickness candidate [tb]:

= min[tb3, max(tb1,tb2)]
= min[6.42, max(6.3379, 4.5)]
= 6.3379 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

= max(ta, tb)
= max(3.2827, 6.3379)
= 6.3379 mm

Available Nozzle Neck Thickness = $0.875 \times 8.738 = 7.645$ mm --> OK**Weld Size Calculations. Description: N8-50-SPARE**

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	$4.0163 = 0.7 \times t_{min}$	$7.0700 = 0.7 \times W_o$ mm

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles
exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

Maximum Allowable Pressure for this Nozzle at this Location:Converged Maximum Allowable Pressure in the Operating case: 7 kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

The Drop for this Nozzle is : 14.8084 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 175.9027 mm

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(ITEM NO.412-H-1001-V01)

Rev.0

DECOKING DRUM

PV Elite 24 Licensee: #BHEL-HPVP-Vizag

FileName : Decoking Drum_R0-28072023 -----

Problems/Failures Summary: Step: 34 3:11pm Jul 28,2023

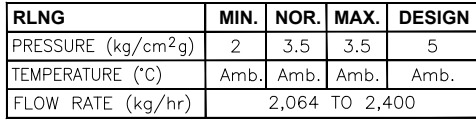
Noted issues for the current model:

Listed below are the known problem areas for the current design. If one or more of the design flags are turned on, please re-run the analysis. Some of these issues may be resolved when using updated input values.

***** Warning: Wind/Earthquake Deflection Exceeded the Specified Allowable!***

Please review all reports carefully!

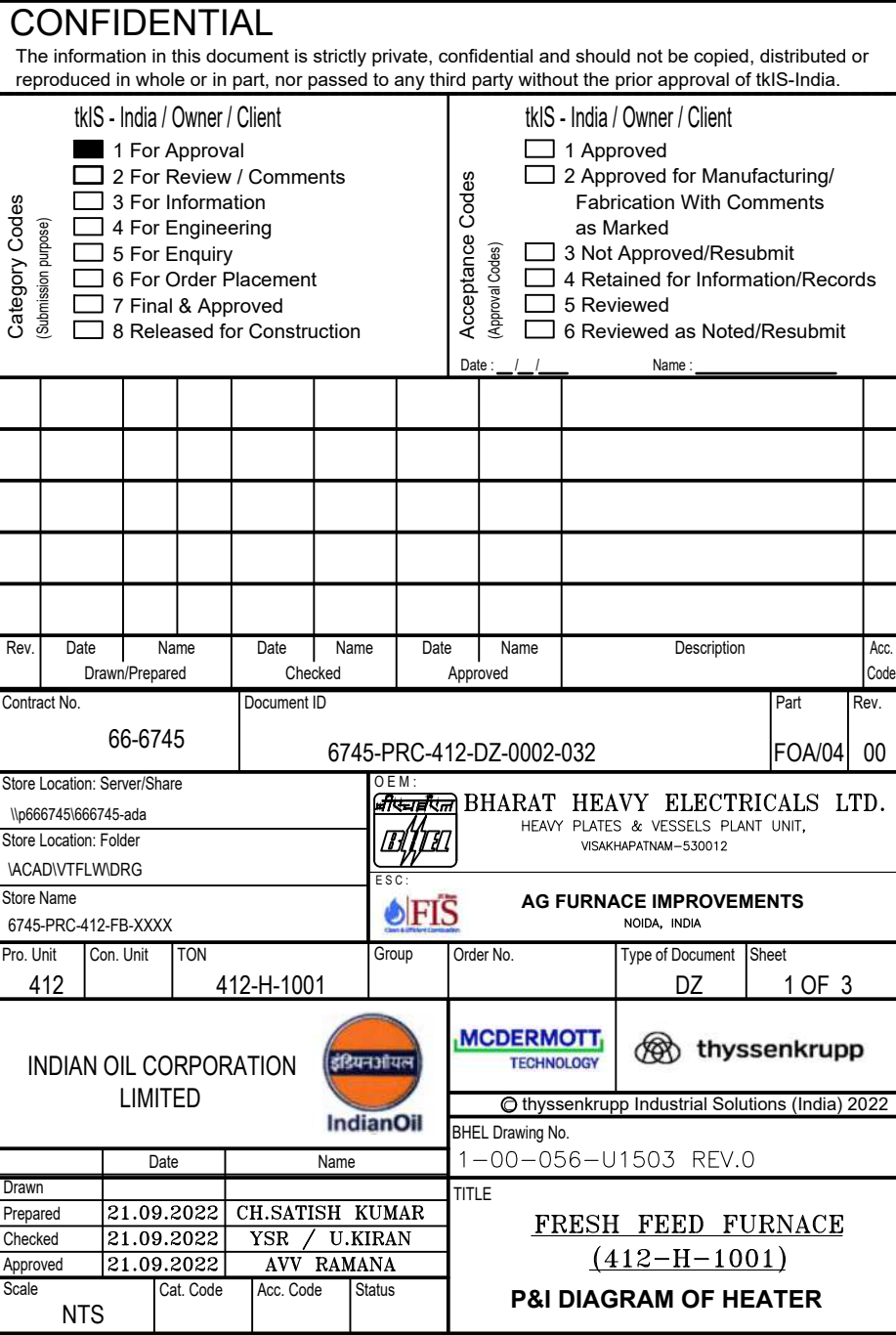
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Note : X : Applicable

1. ALL CV, ON/OFF, SAPCV, TW/ORIFICE, CONTROL VALVE AND ESD VALVE SHALL BE MINIMUM 300# RATING OR OF PIPING CLASS WHICHEVER IS HIGHER
2. FUEL GAS AND PILOT GAS LINES SHALL HAVE STEAM HEAT TRACING.
3. DCS, PLC, INTERLOCKS, AND CONTROL ROOM DISPLAYS ARE BY OTHERS.
4. TAPPING FOR VENT CONNECTIONS SHALL BE FROM TOP OF PIPE.

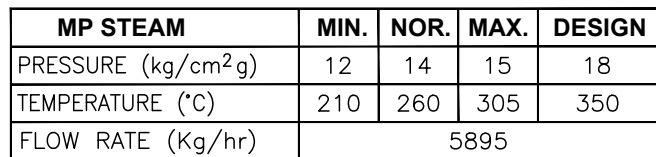
Rev.	Date	Name	Date	Name	Date	Name	Description	Acc.	Code
Drawn/Prepared	Checked	Approved							
Contract No. 66-6745			Document ID 6745-PRC-412-DZ-0002-031					Part FOA/04	Rev. 00
Store Location: Server/Share \\p666745\666745-adv			 BHARAT HEAVY ELECTRICALS LTD. HEAVY PLATES & VESSELS PLANT, VISAKHAPATNAM - 530012						
Store Location: Folder \\ACADIV\TFLWDRG									
Store Name 6745-PRC-412-FB-XXXX			 AG FURNACE IMPROVEMENTS NOIDA, INDIA						
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412		412-H-1001			DZ		1 / 2		
 INDIAN OIL CORPORATION LIMITED			 thyssenkrupp						
			 thyssenkrupp Industrial Solutions (India) 2022						
BHEL Drawing No.			2-00-056-U1502 REV.0						
Drawn	Date	Name							
Prepared	20.09.2022	CH.SATISH KUMAR							
Checked	20.09.2022	YSR / U.KIRAN							
Approved	20.09.2022	AVV RAMANA							
Scale	Cat. Code	Acc. Code	Status	P&I DIAGRAM OF FUEL GAS SYSTEM					
NTS									

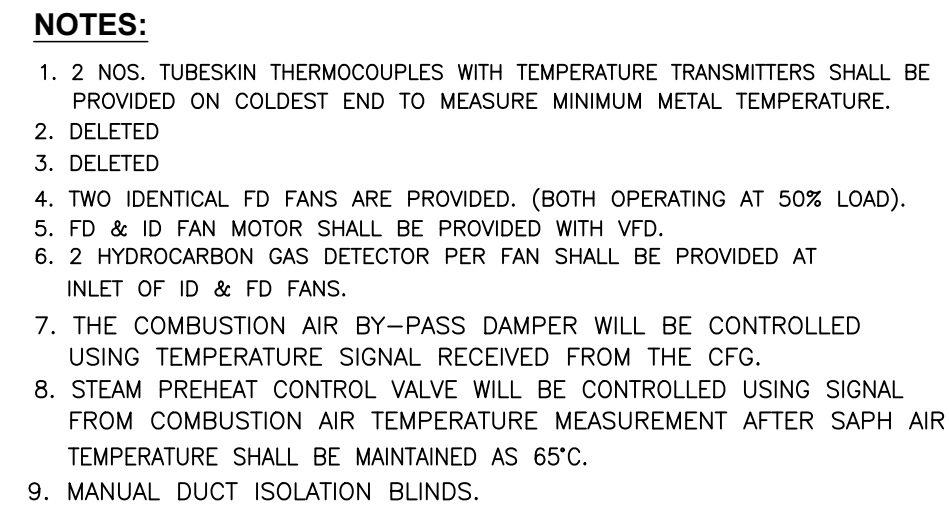


FRESH FEED FURNACE (412-H-1001)
(RADIANT & CONVECTION SECTION)

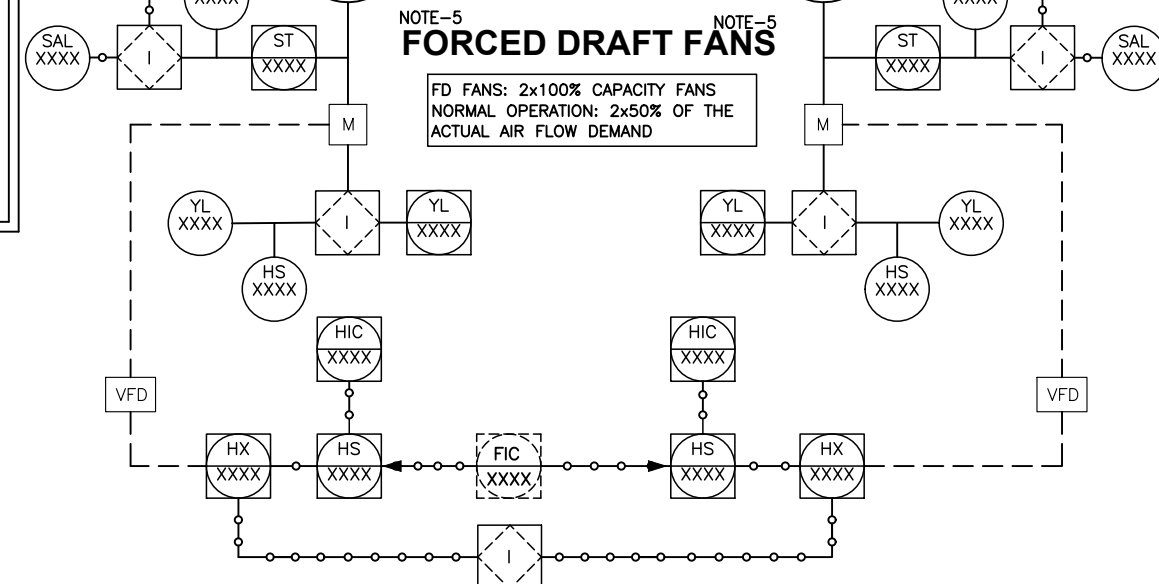
SCOPE LEGEND:

 CUSTOMER/PMC | BHEL





MP STEAM	MIN.	NOR.	MAX.	DESIGN
PRESSURE (kg/cm ² g)	12	14	15	18
TEMPERATURE (°C)	210	260	305	350
FLOW RATE (Kg/hr)	—	1300	—	—

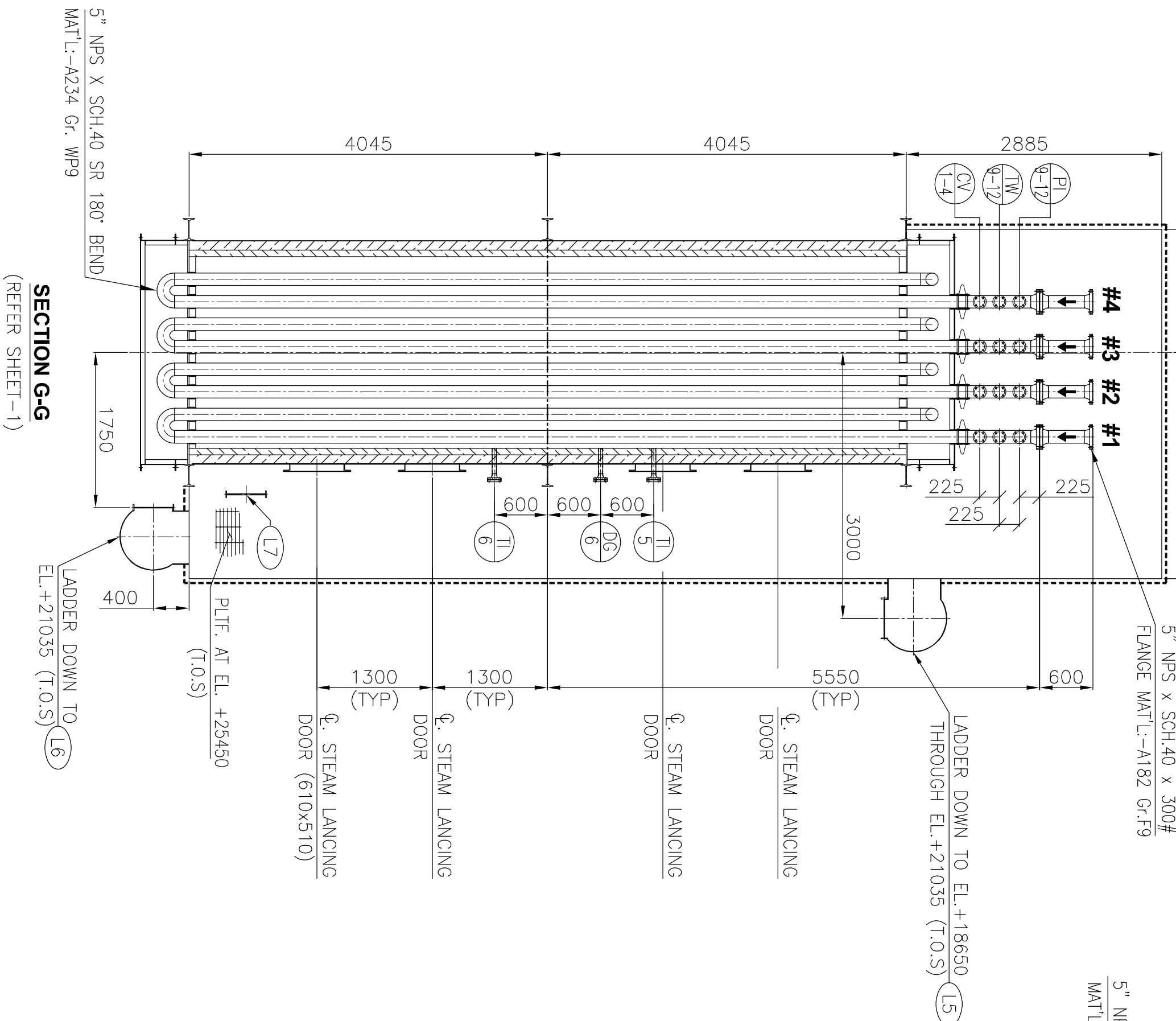
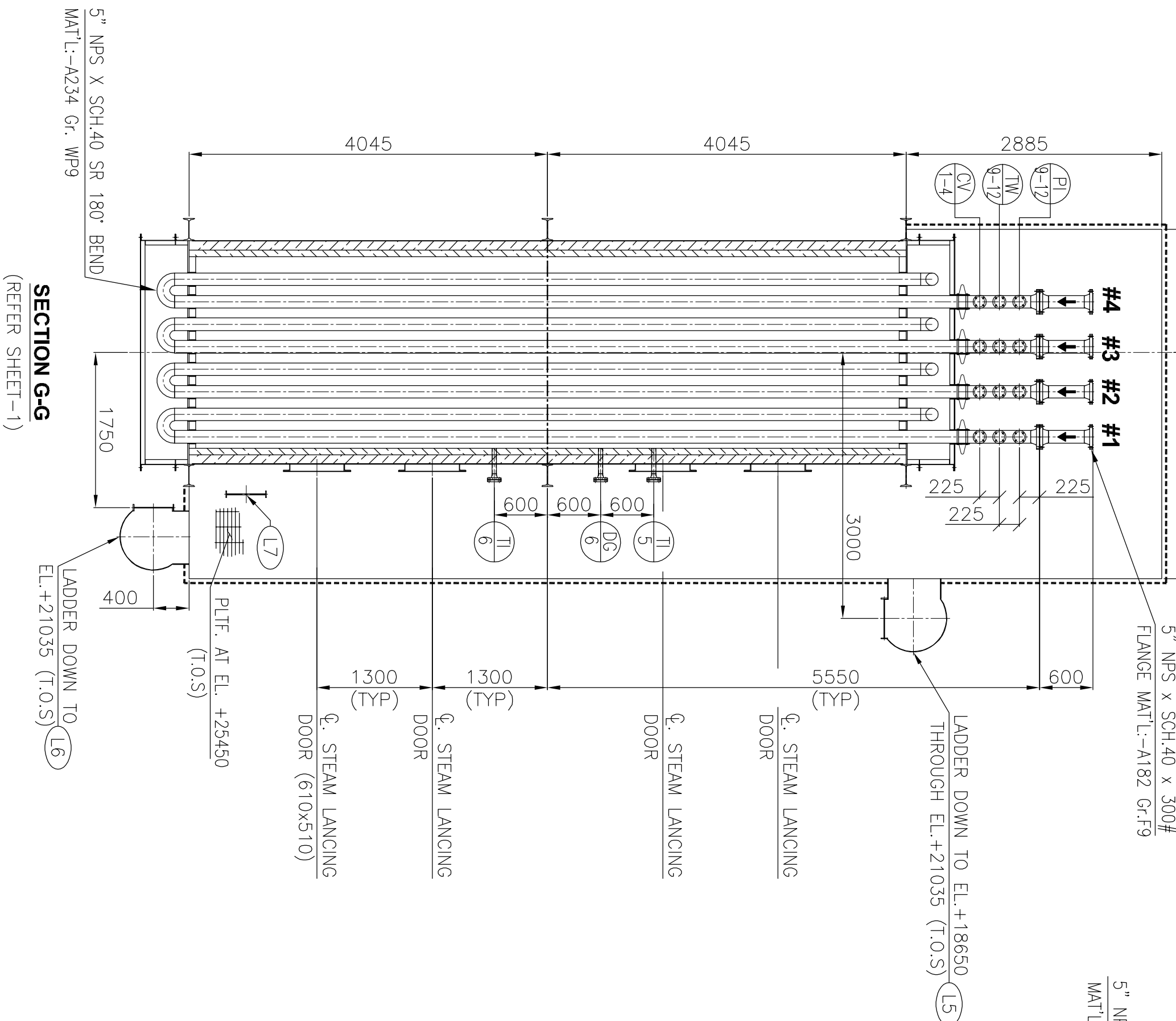
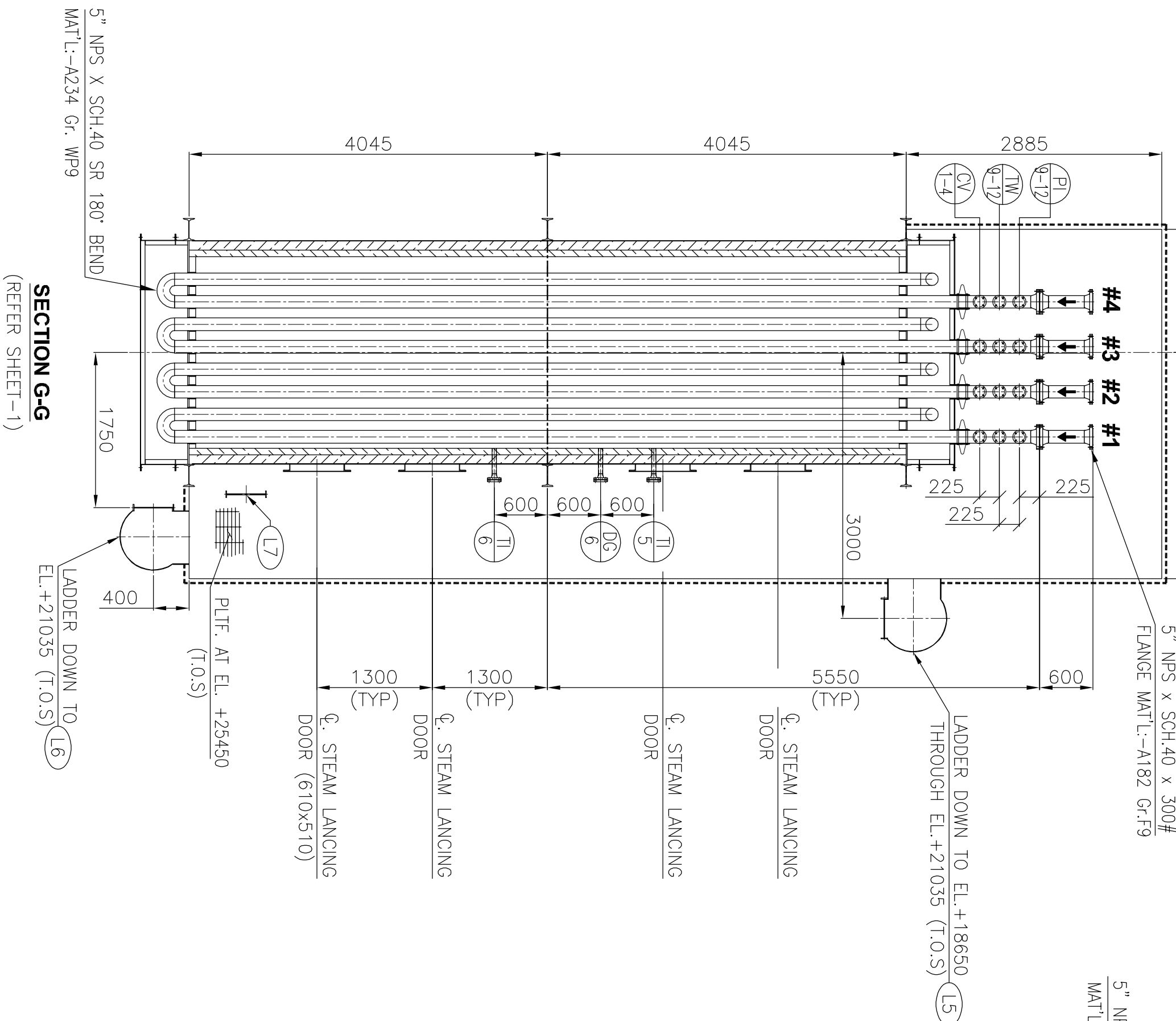
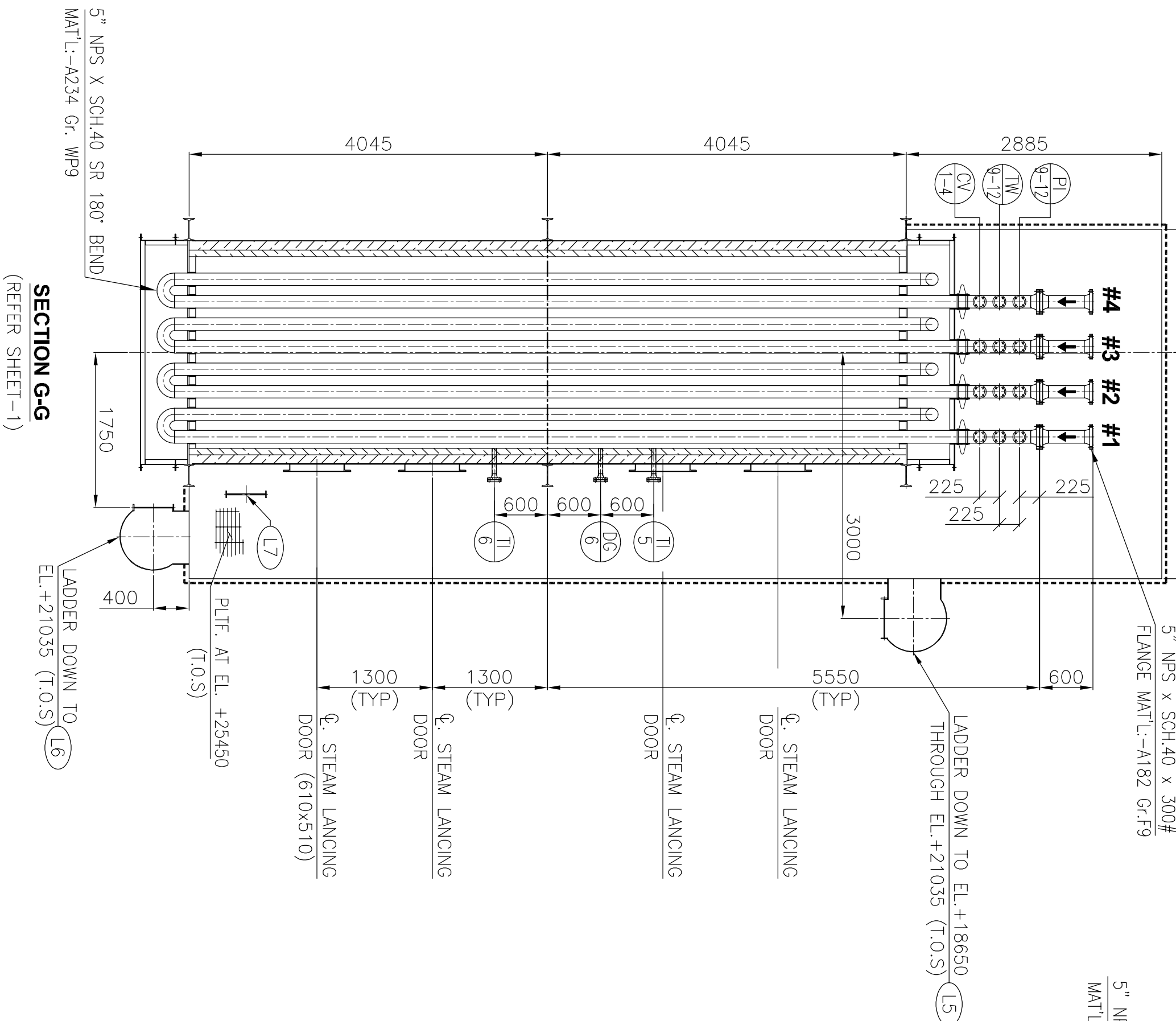
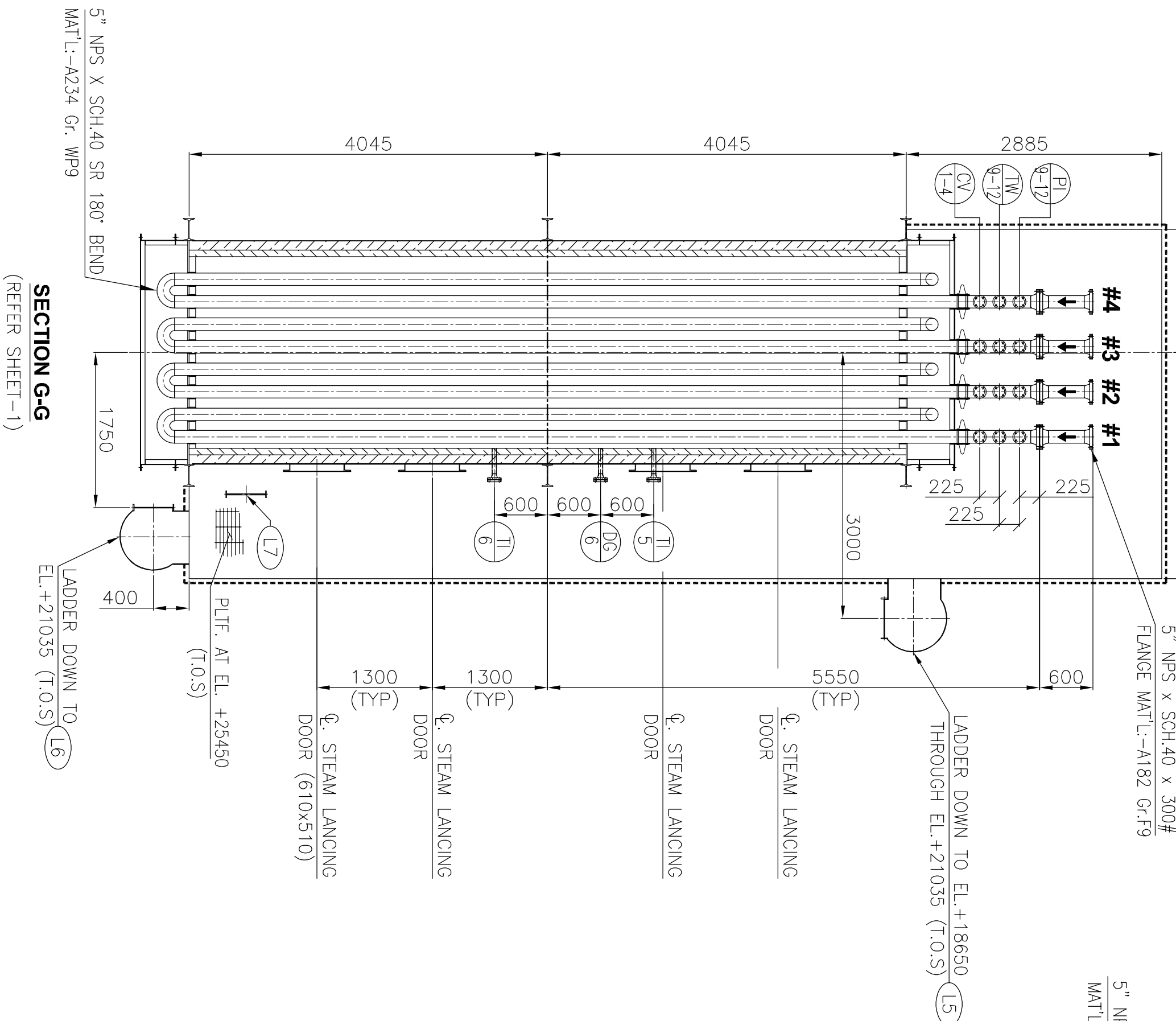
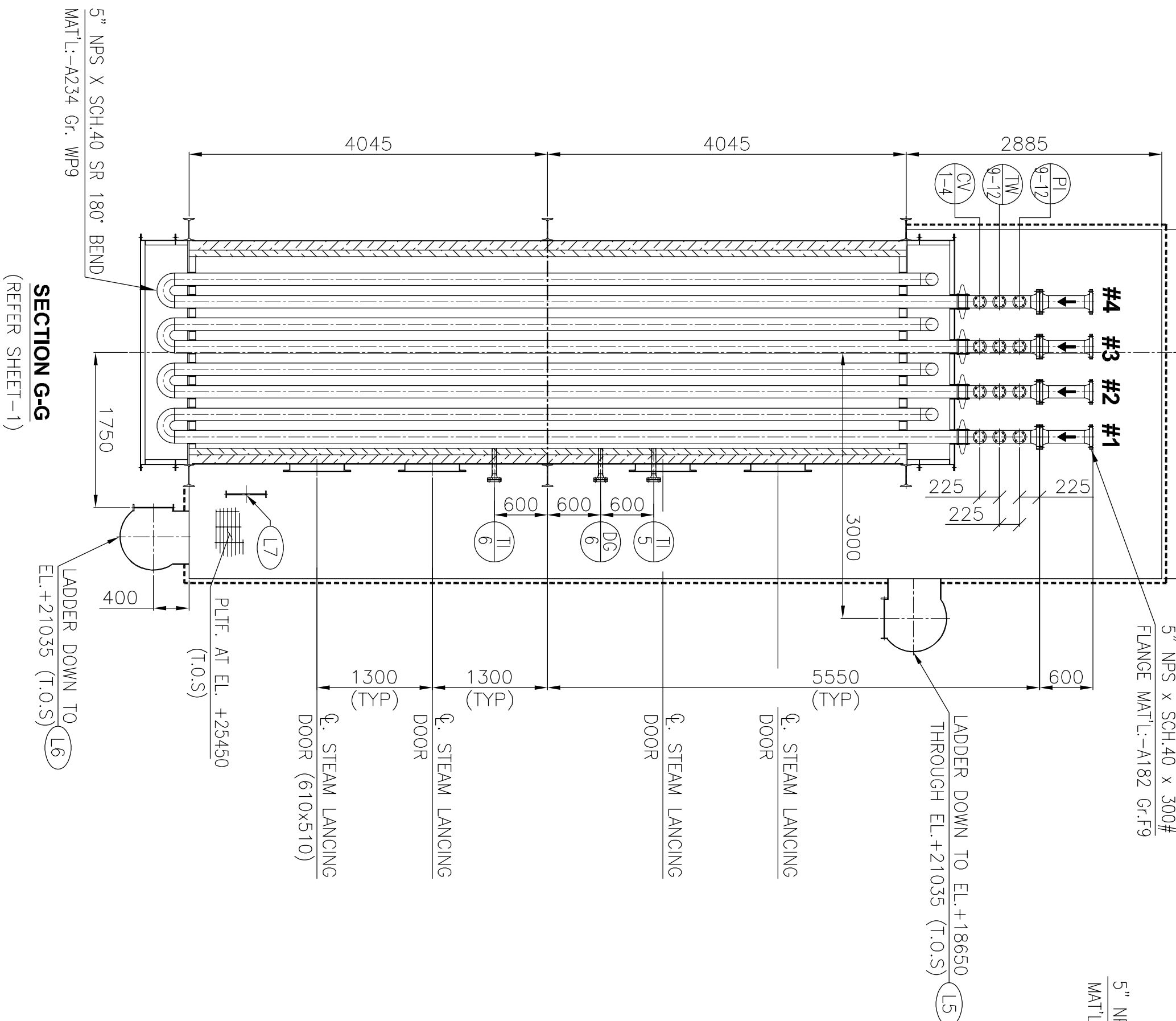
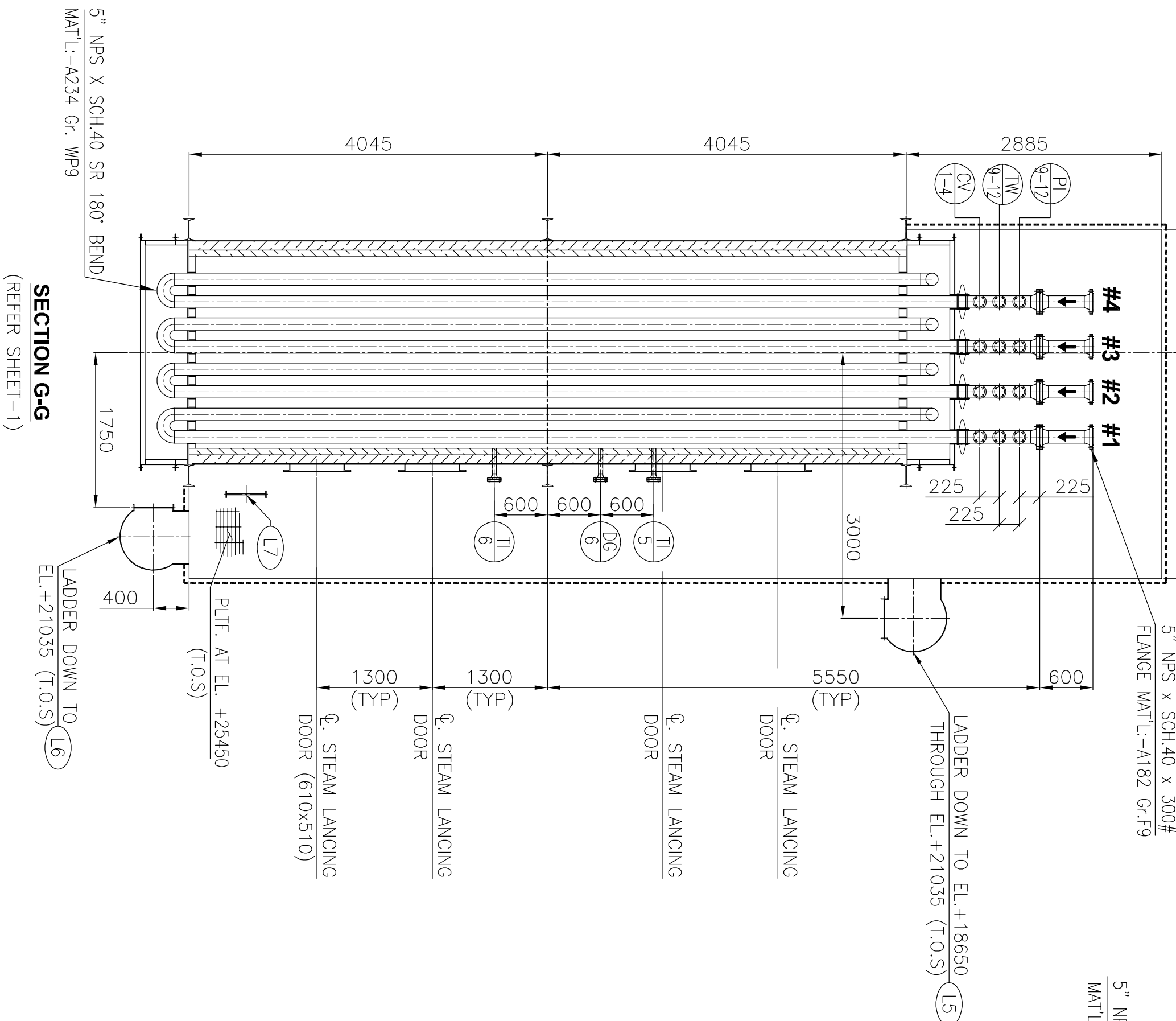
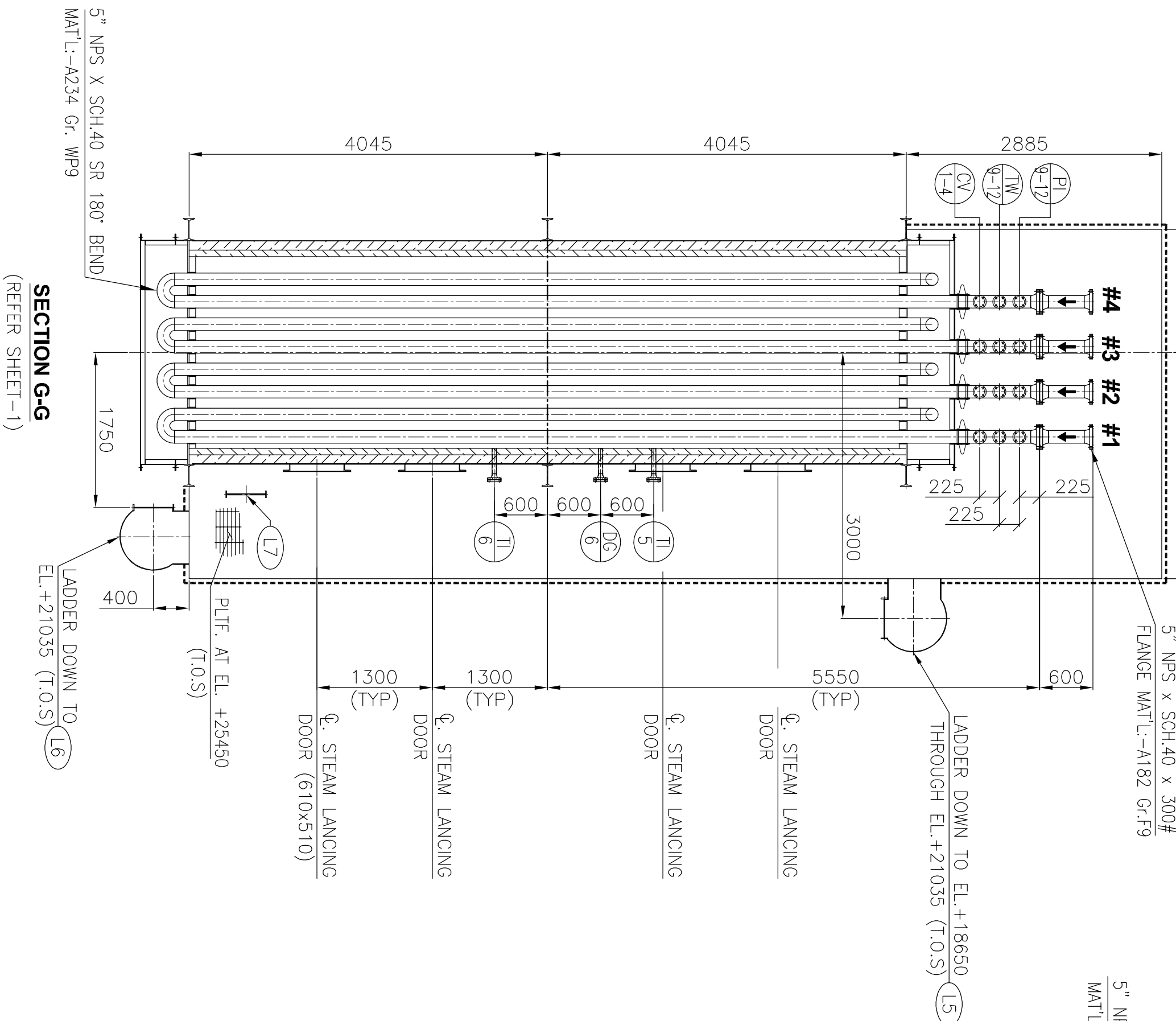
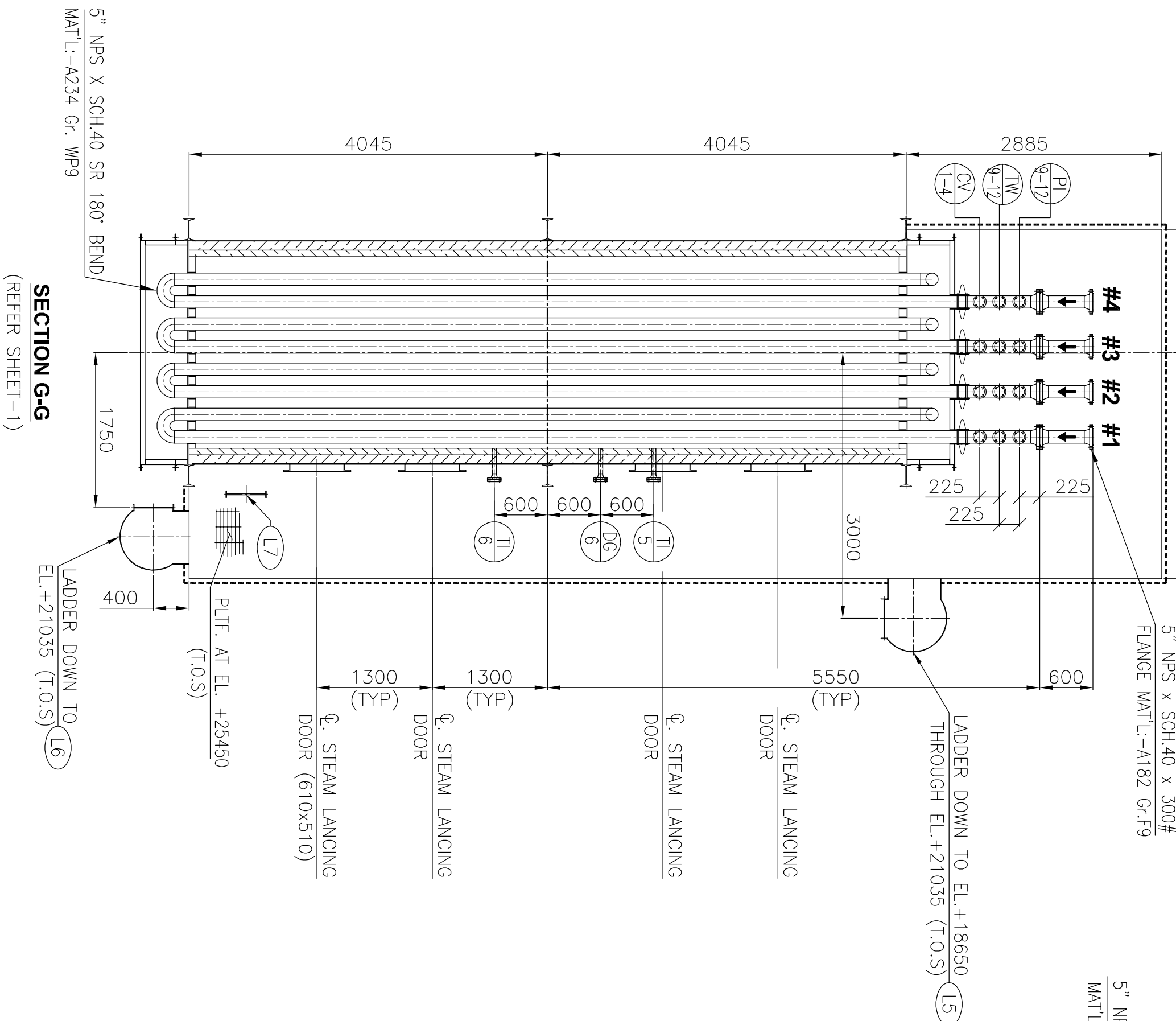
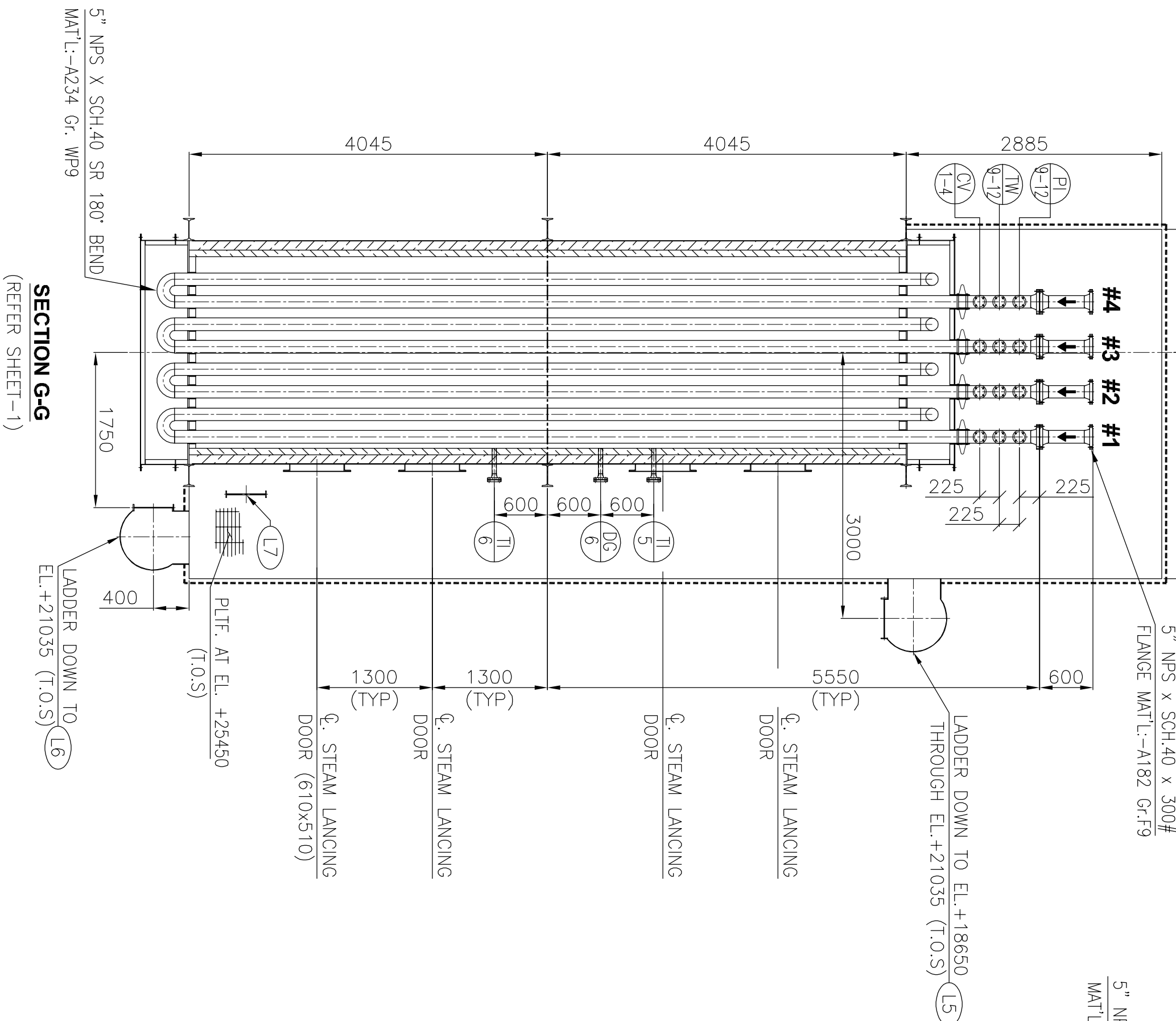
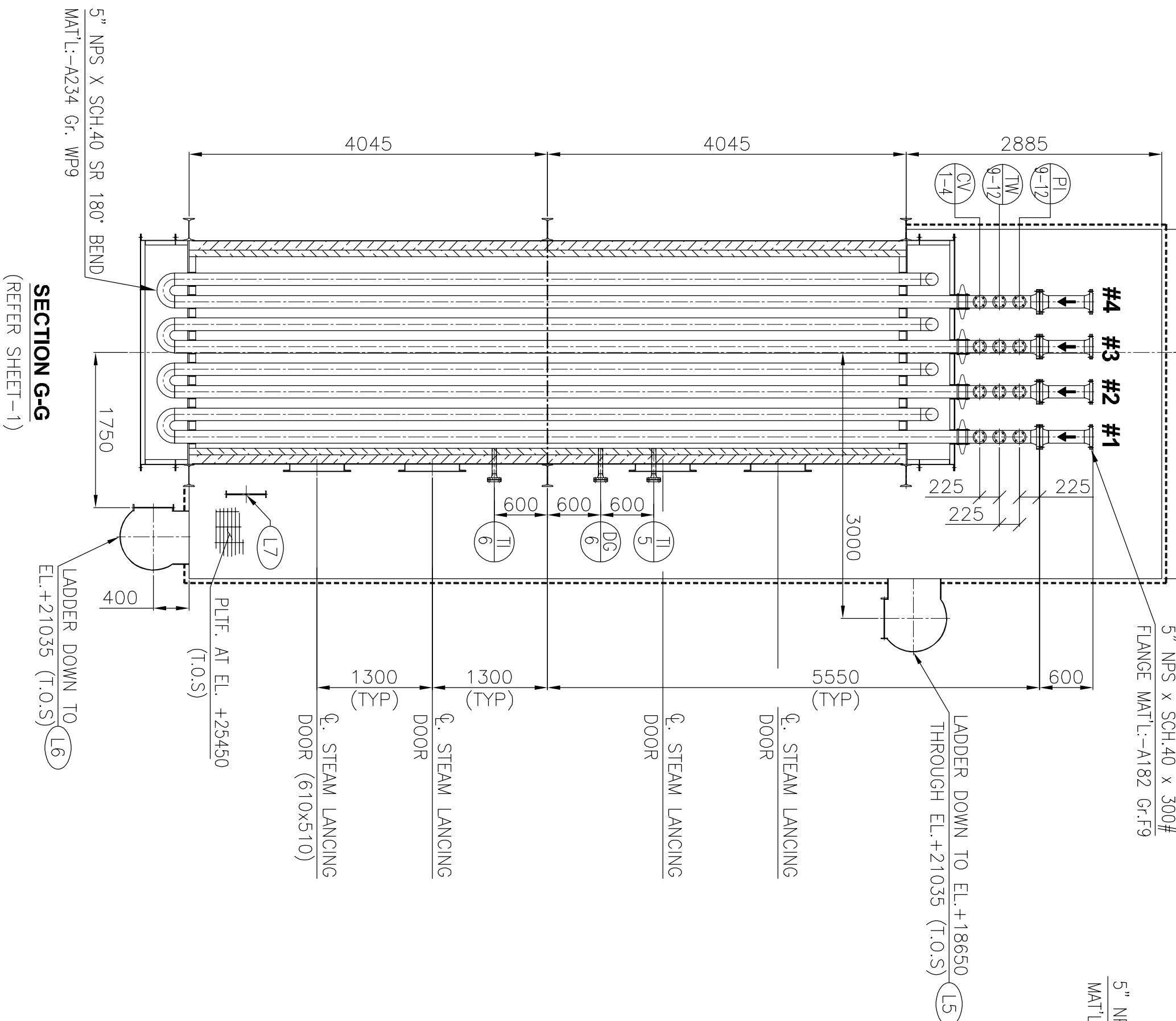
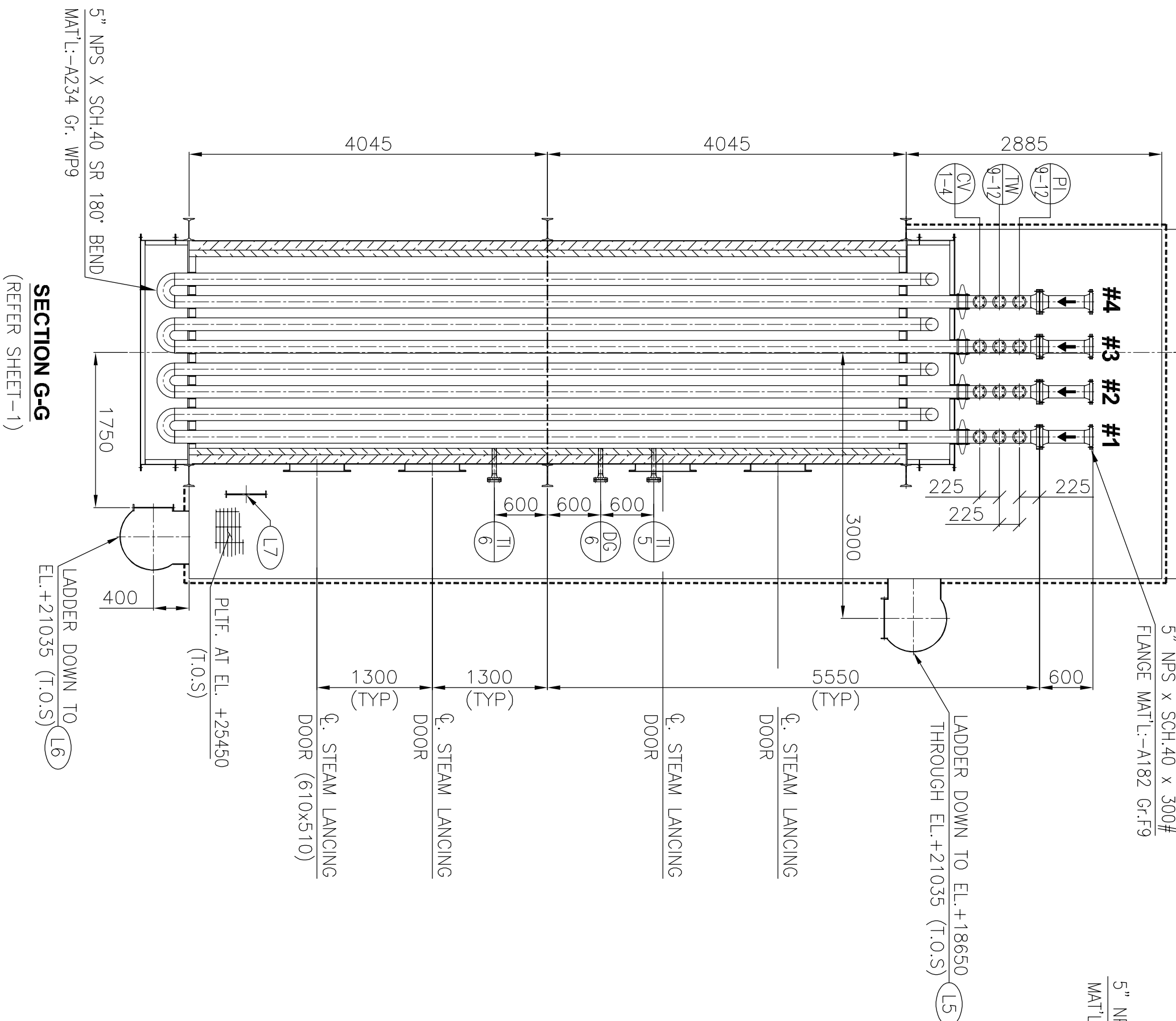
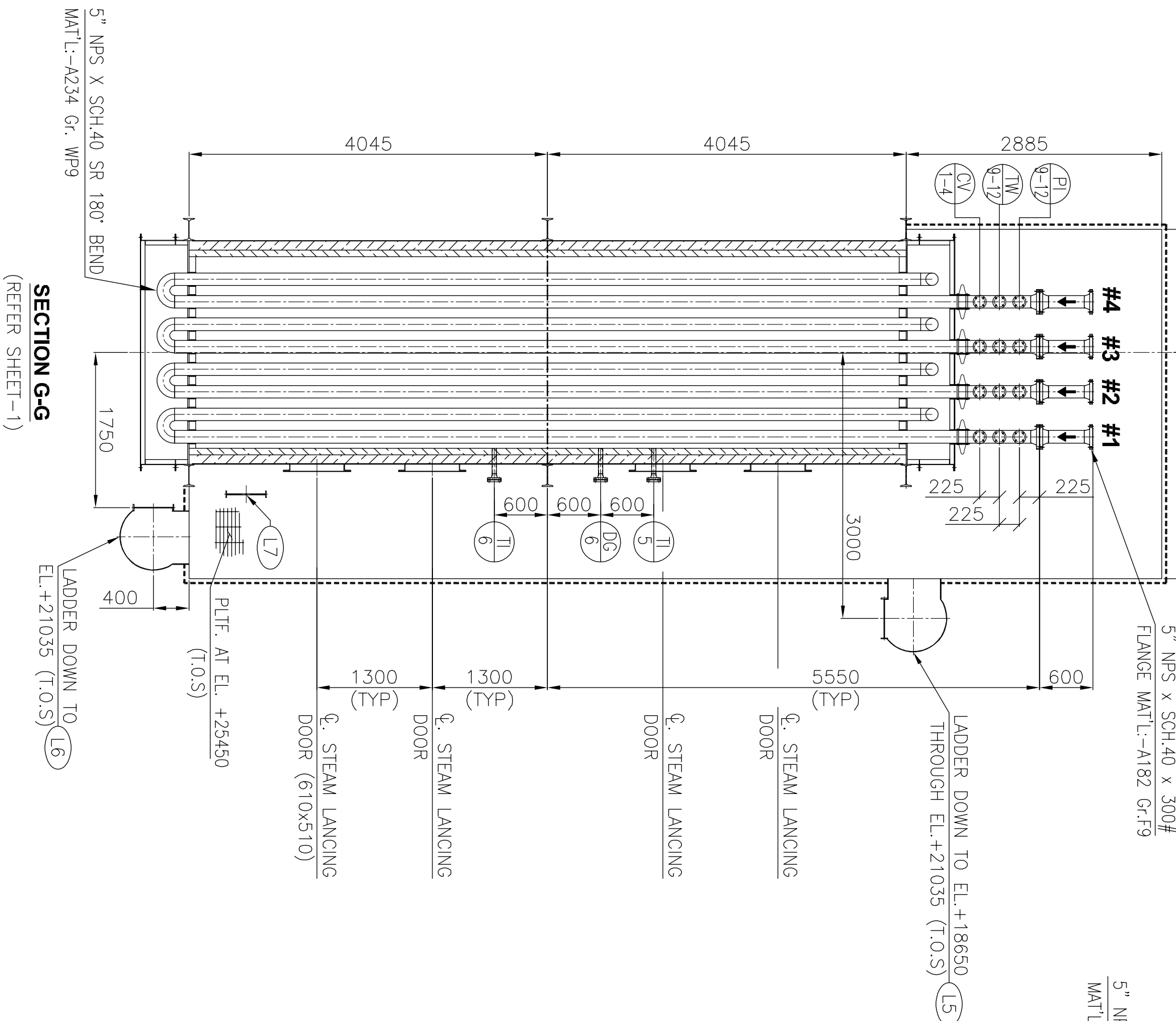
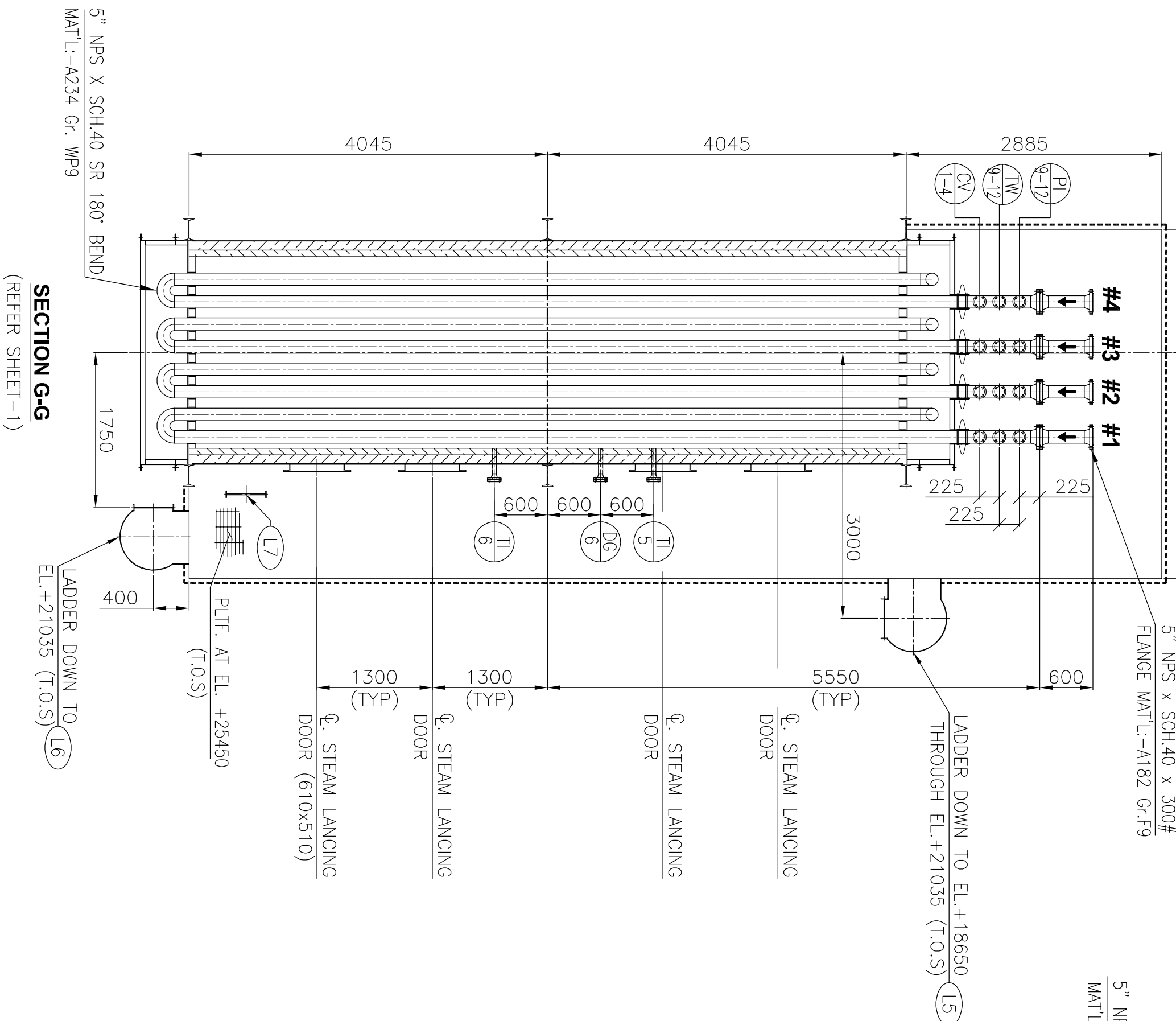
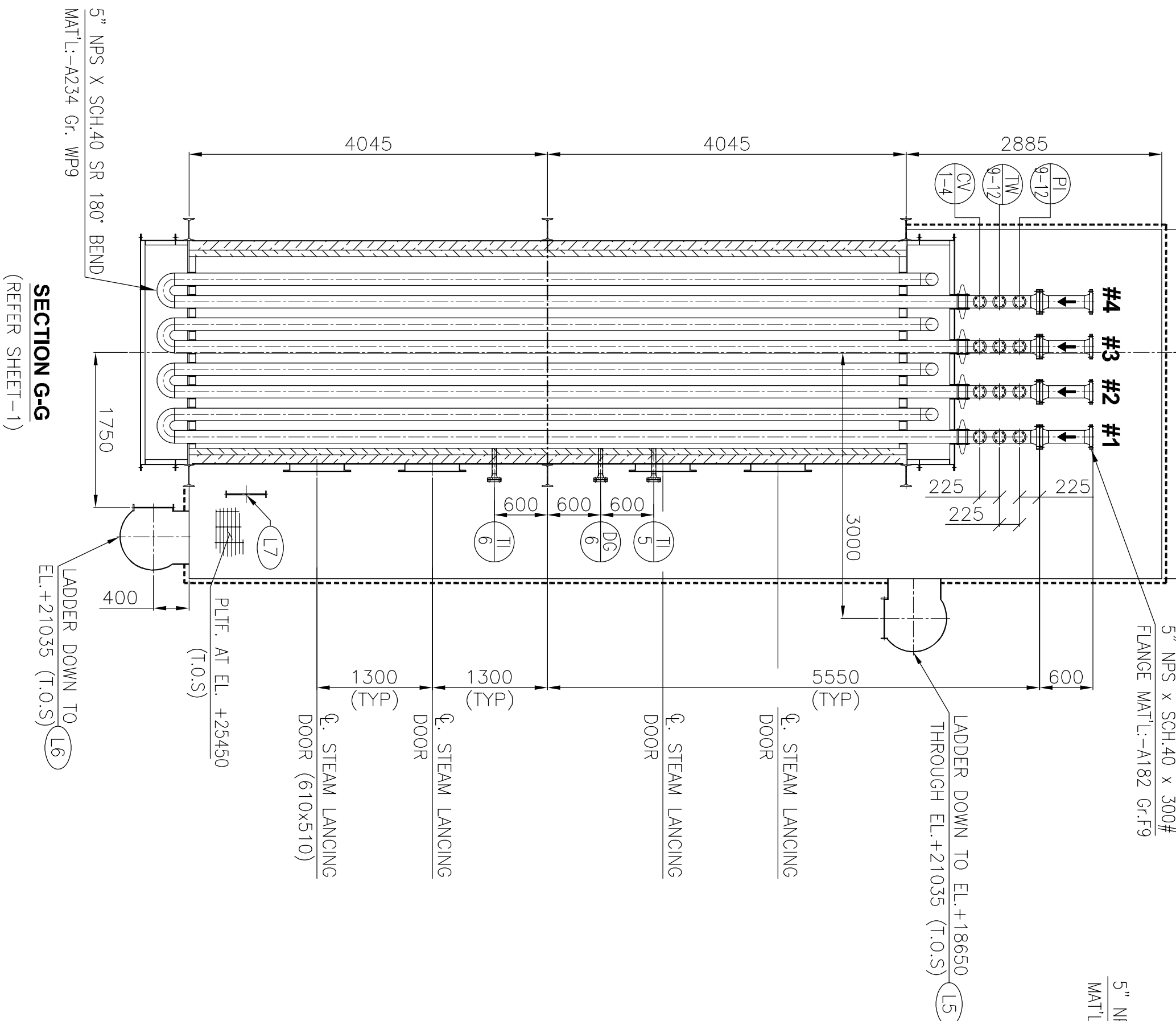
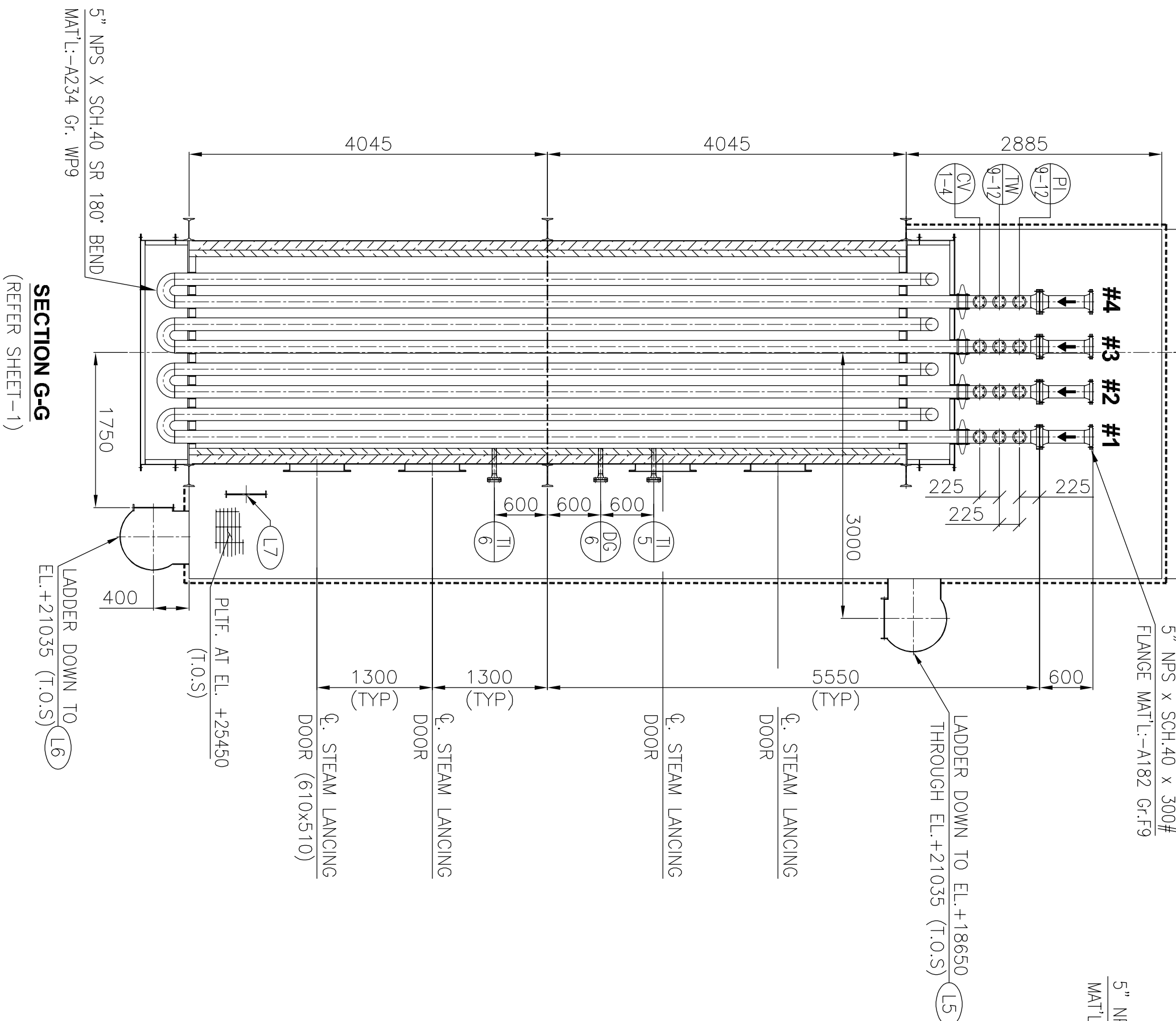
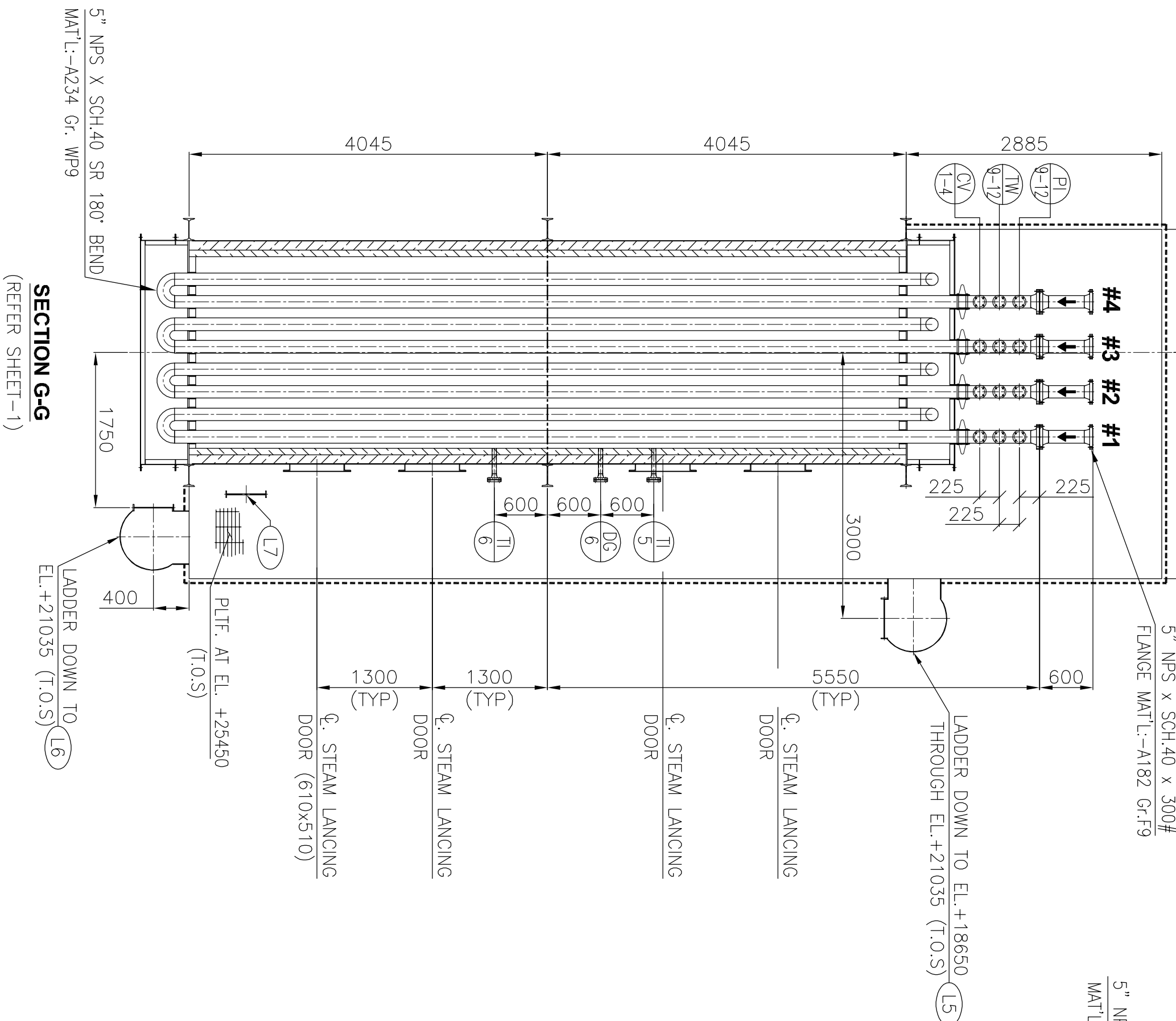
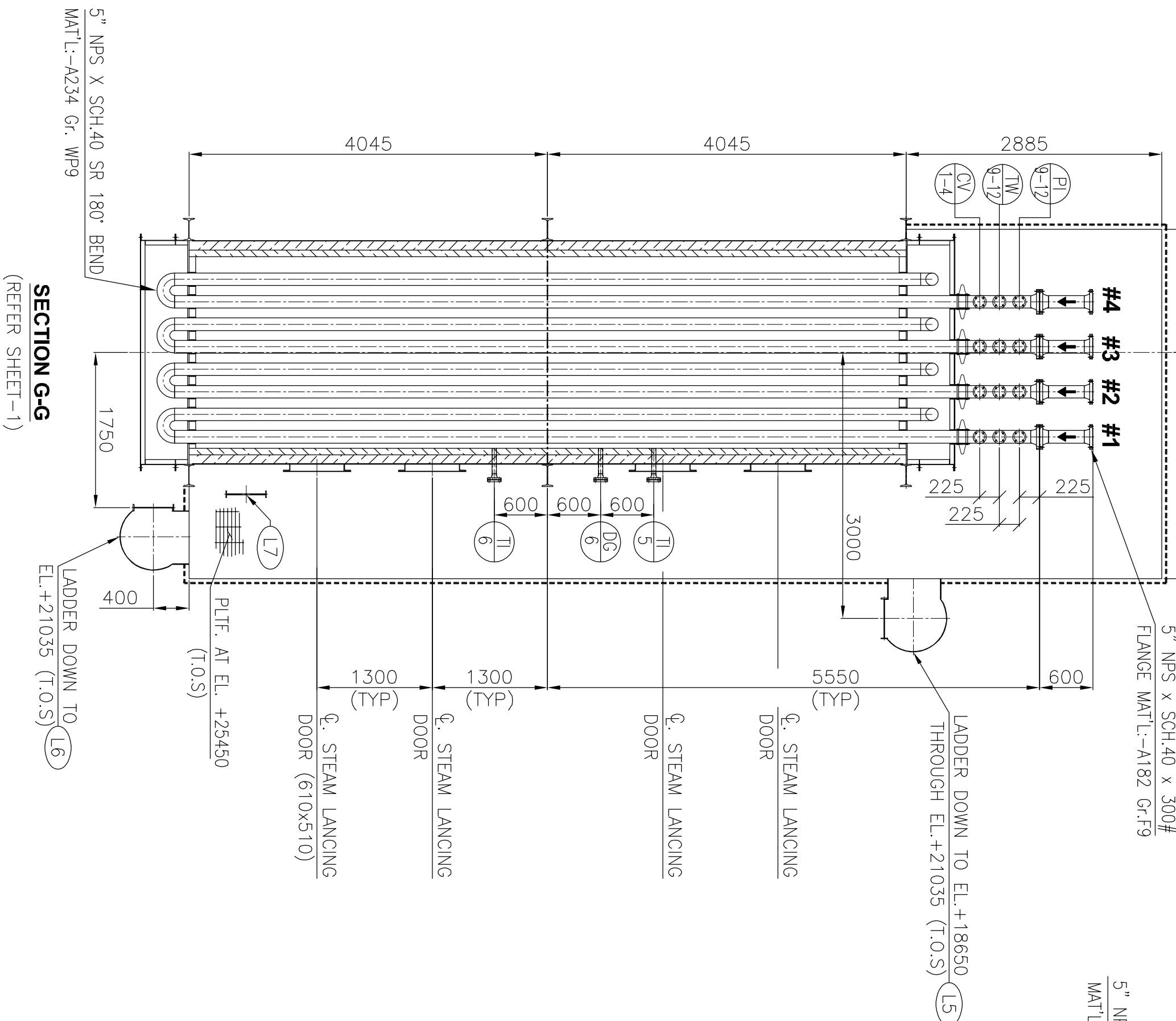
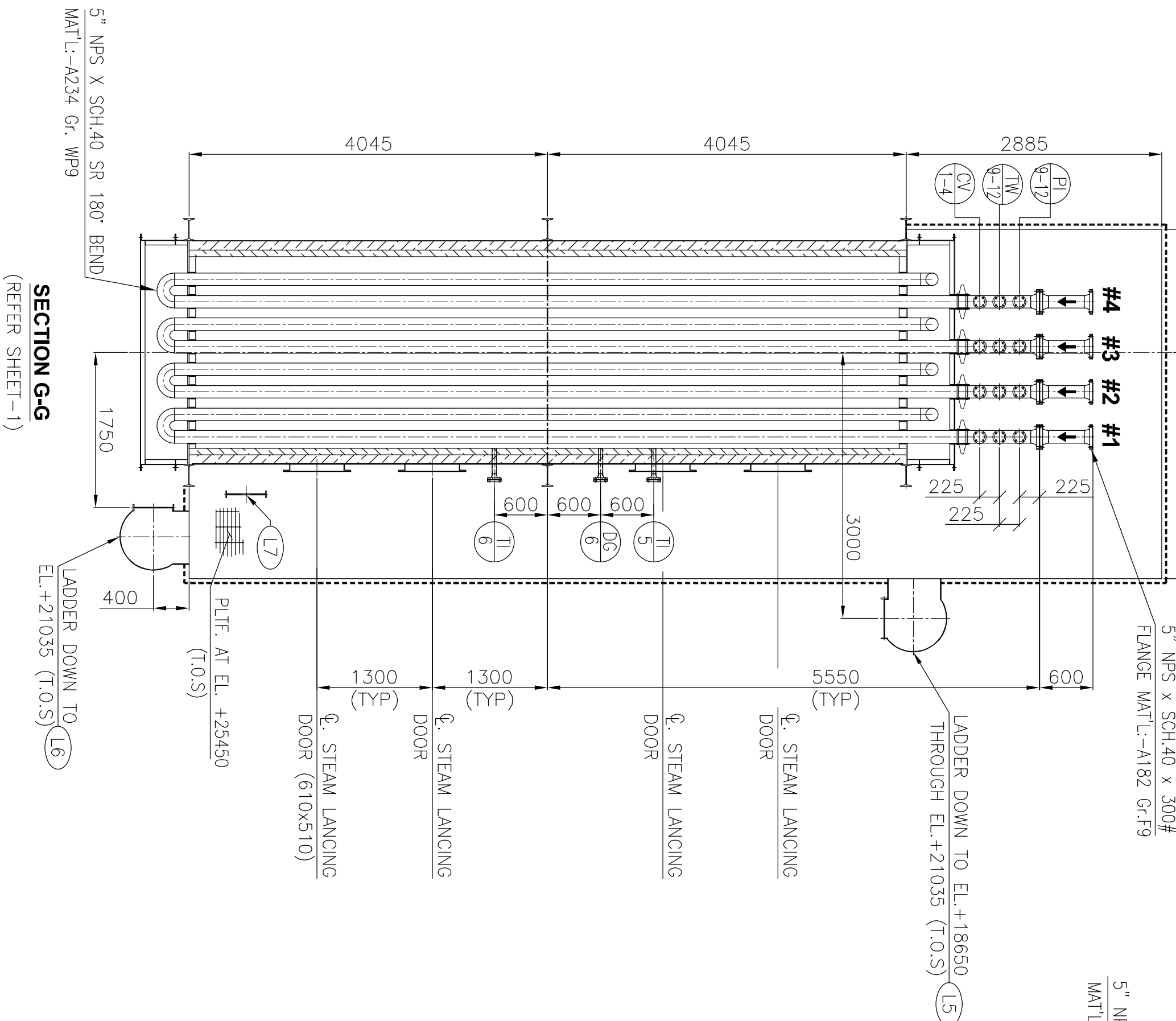
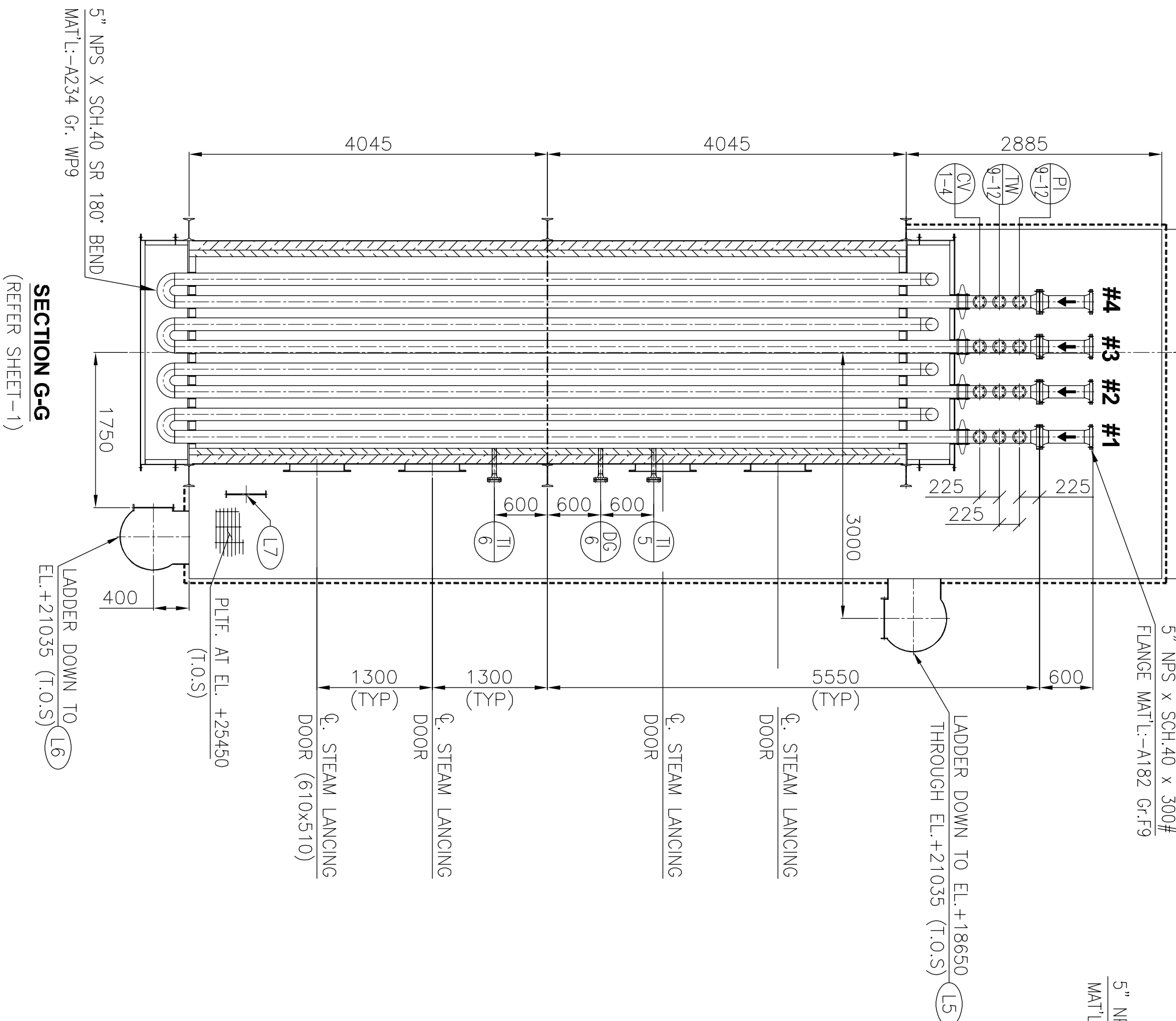
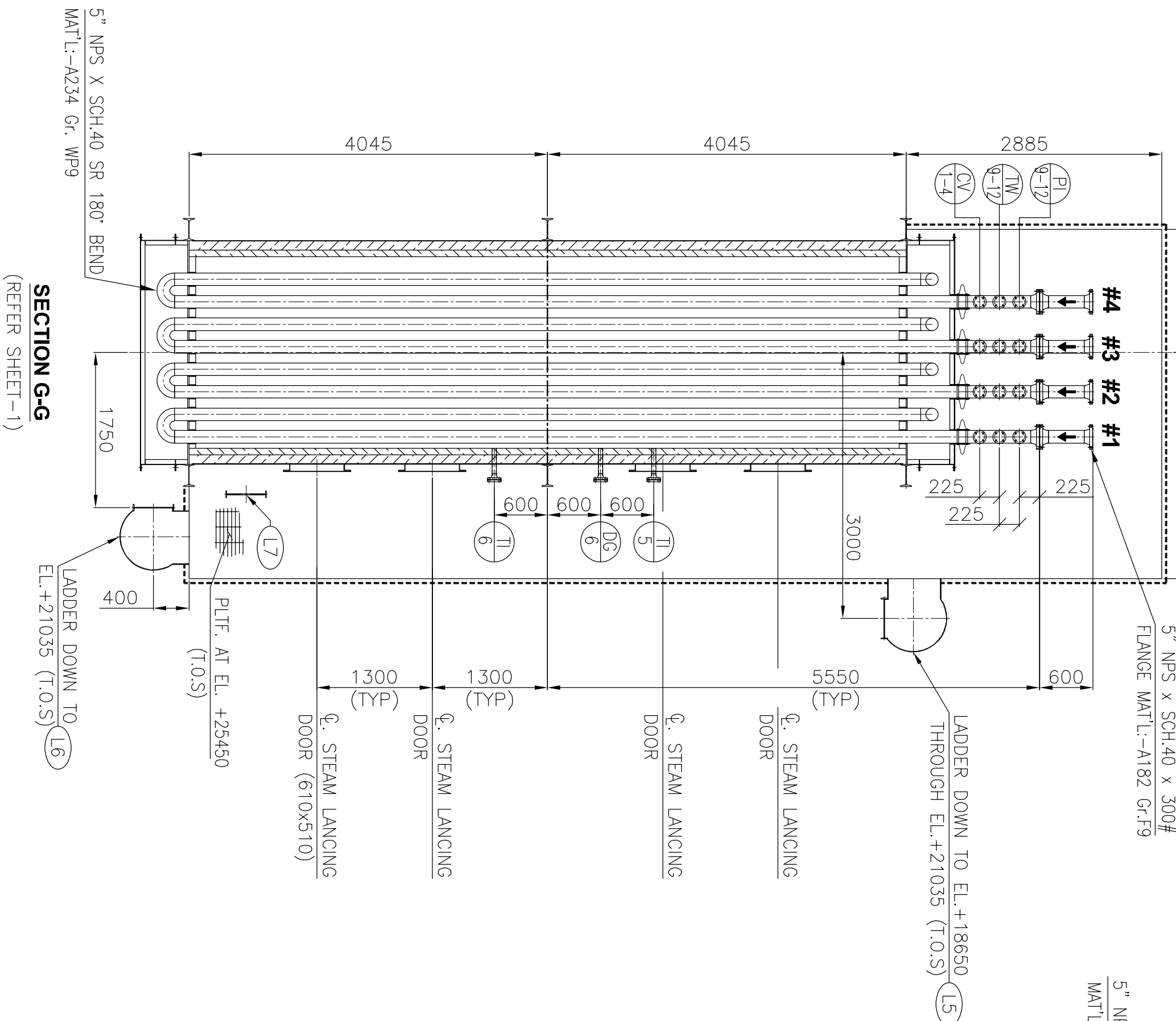
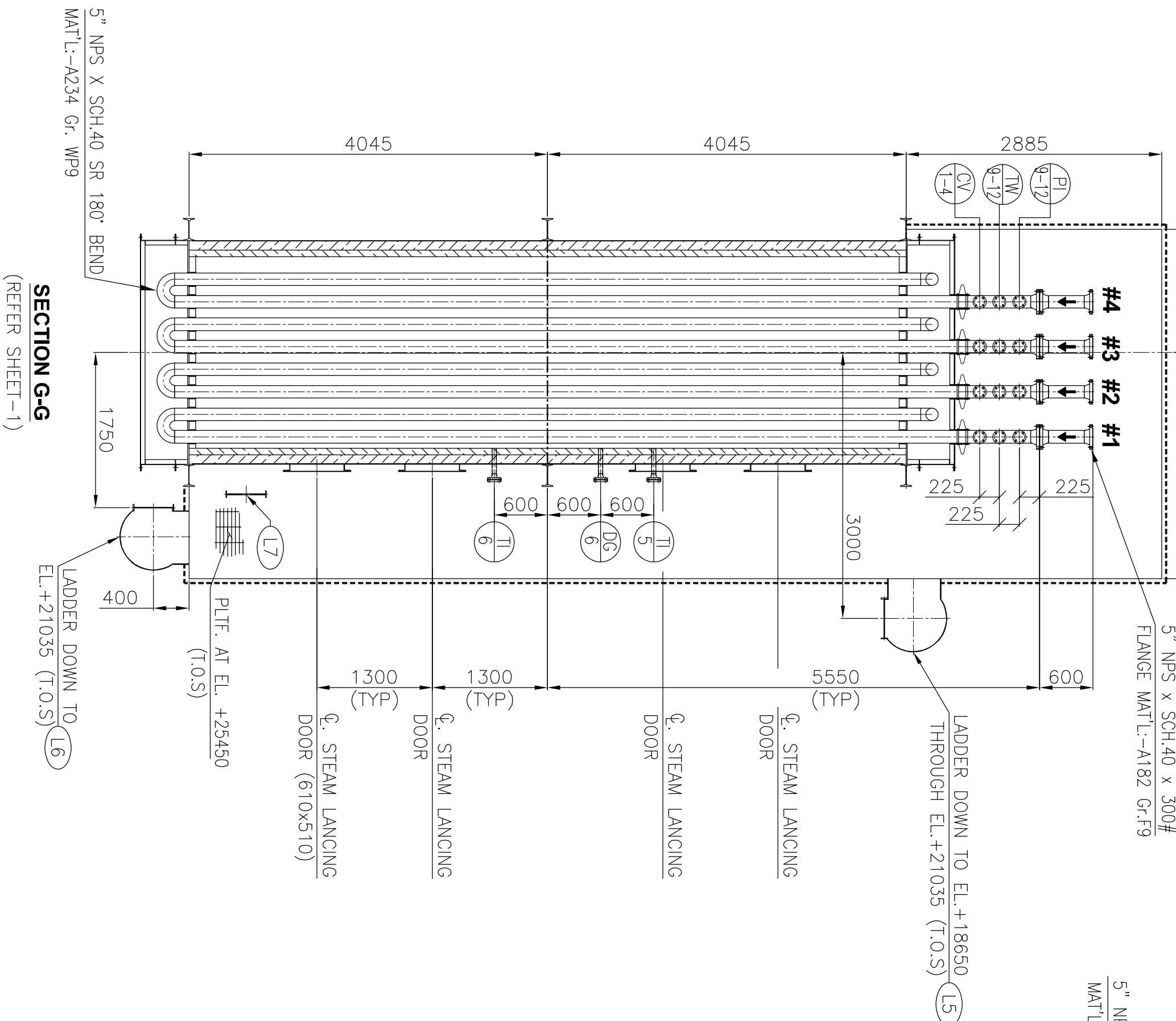
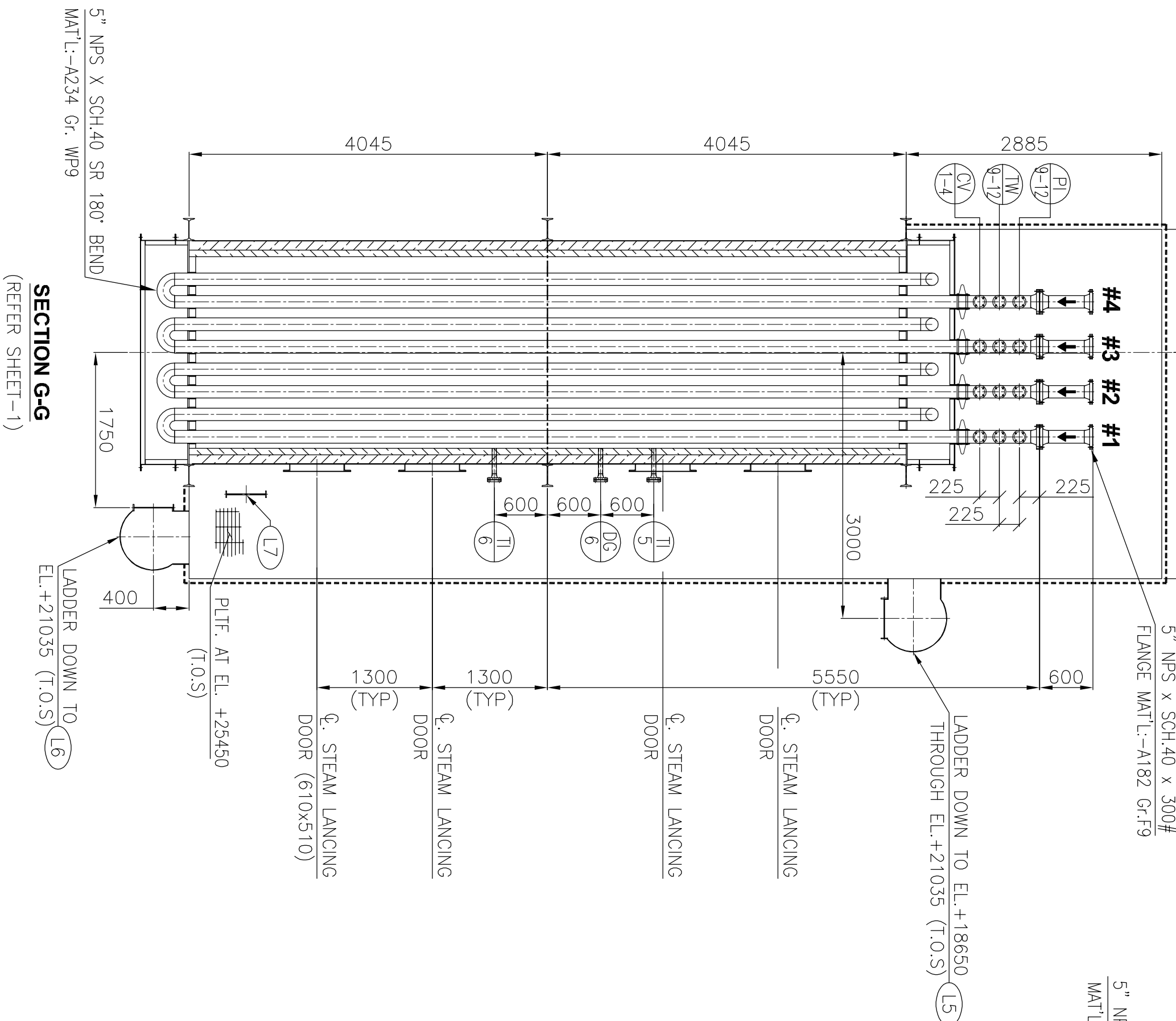
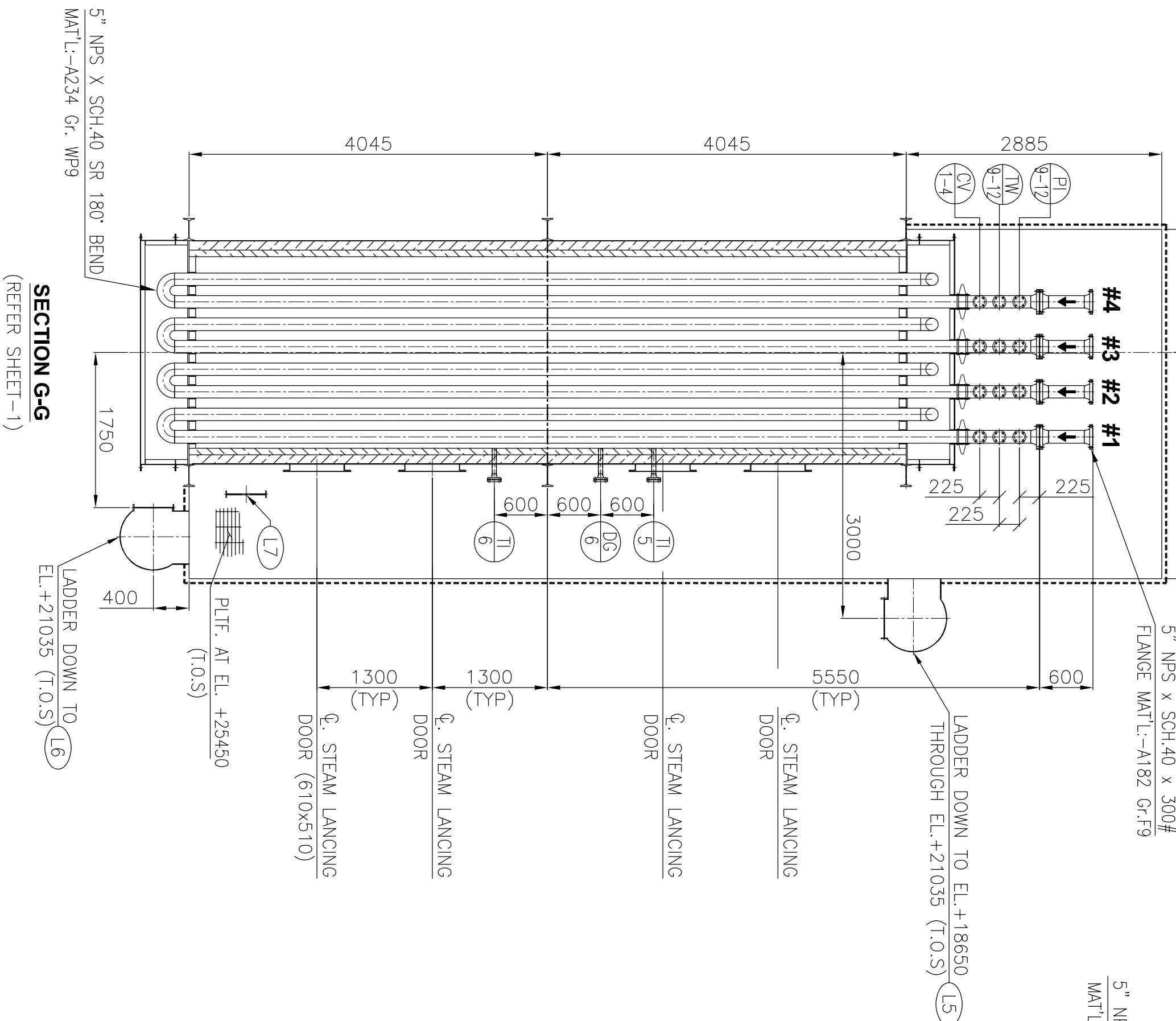
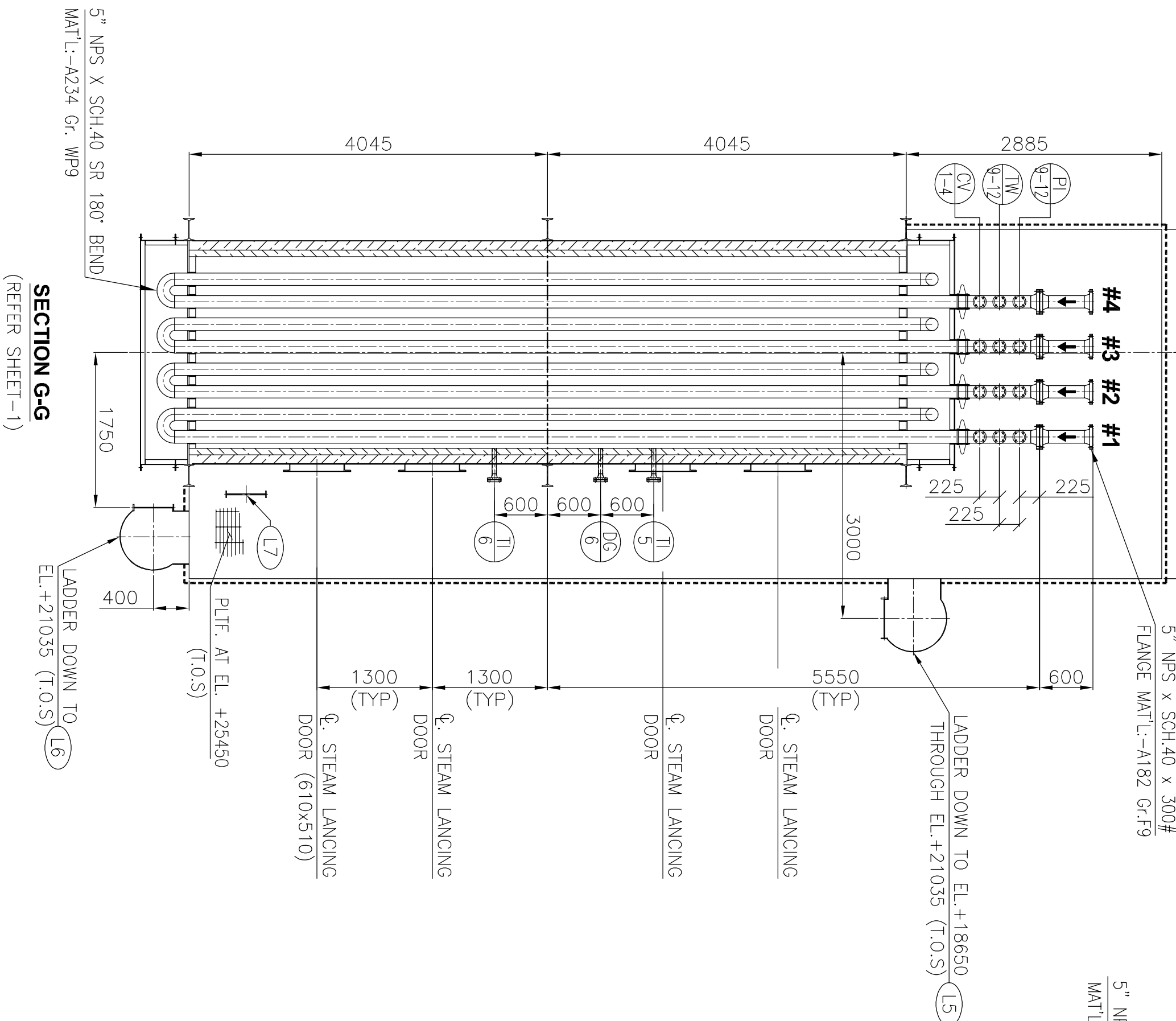
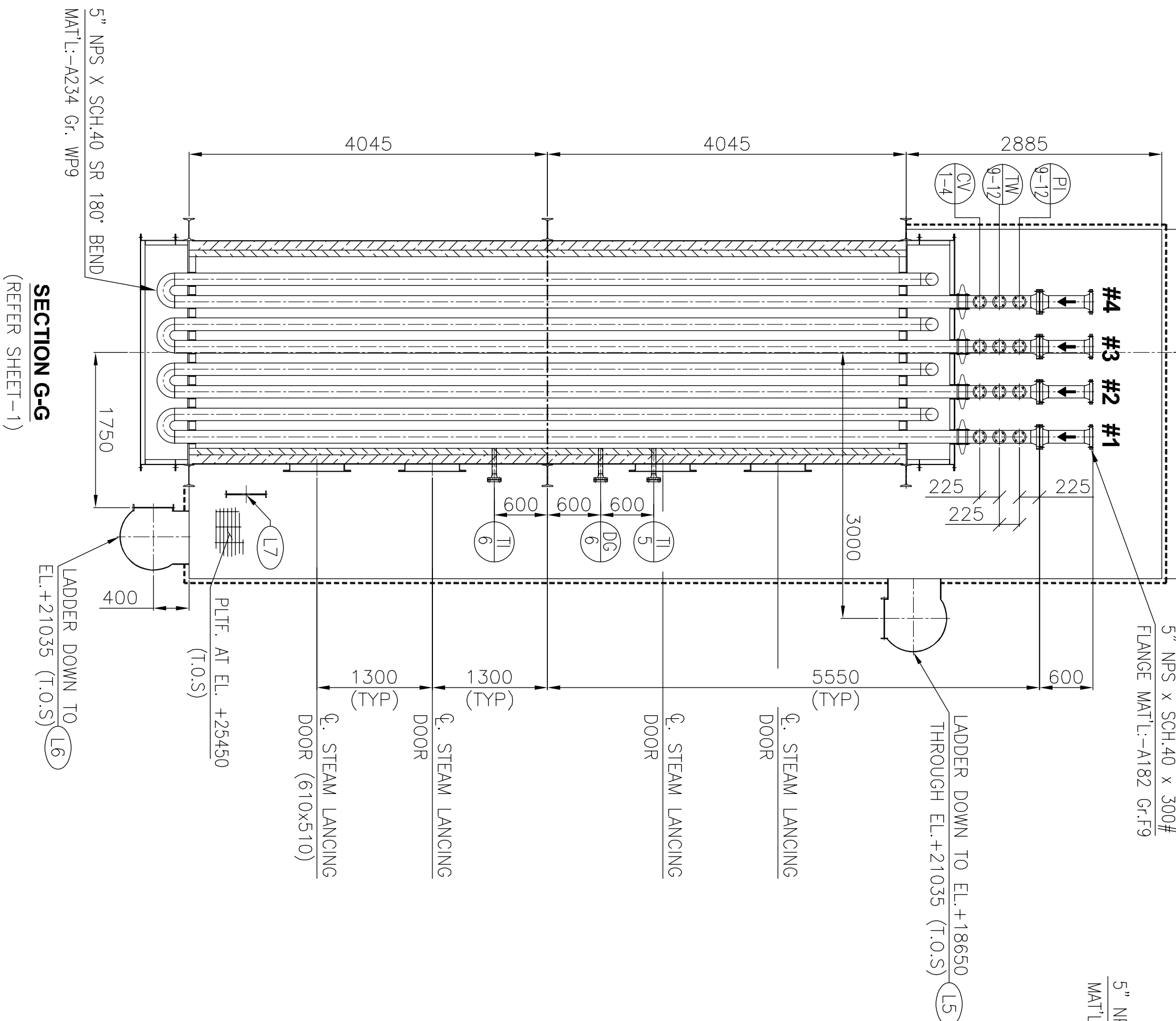
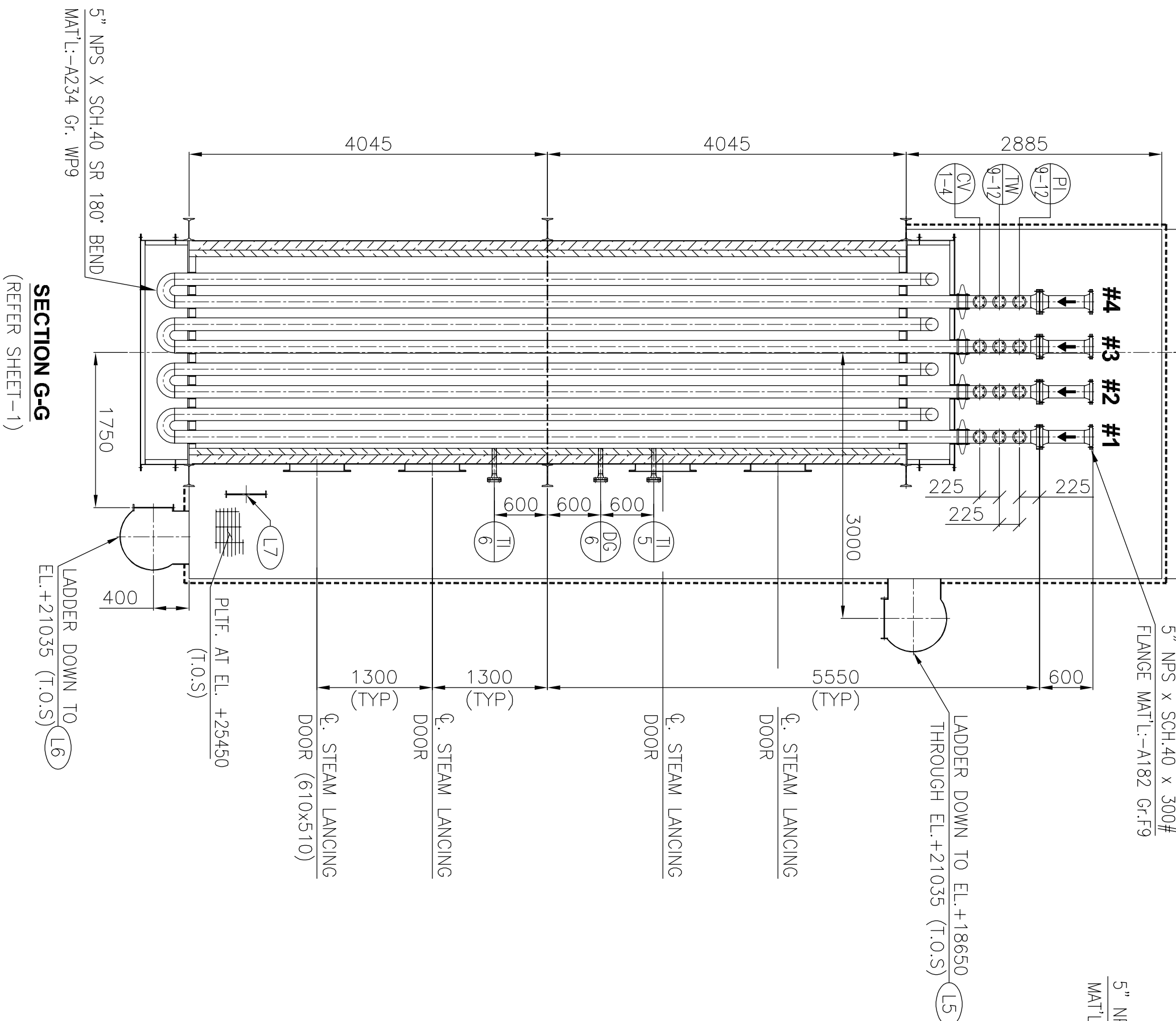
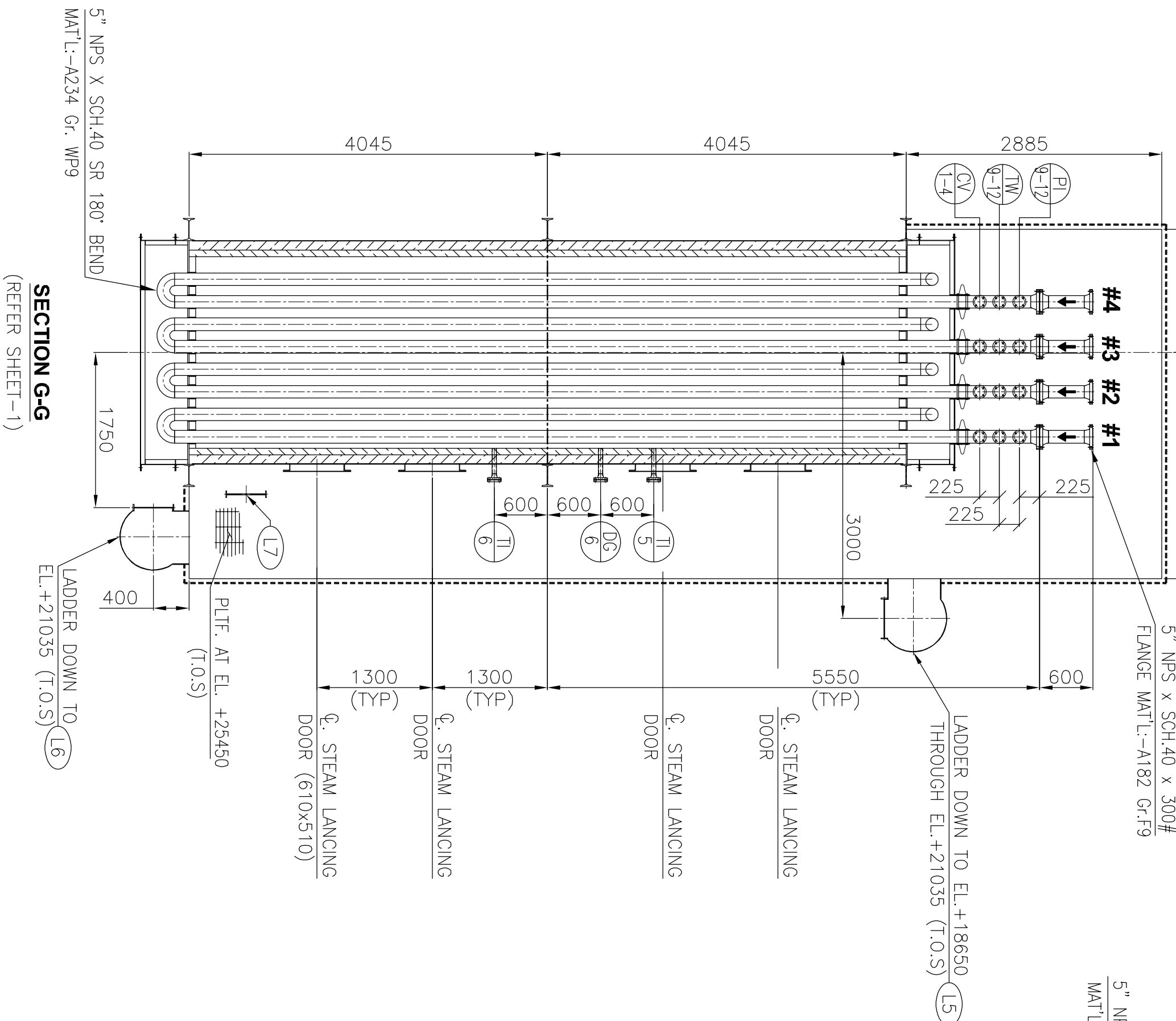
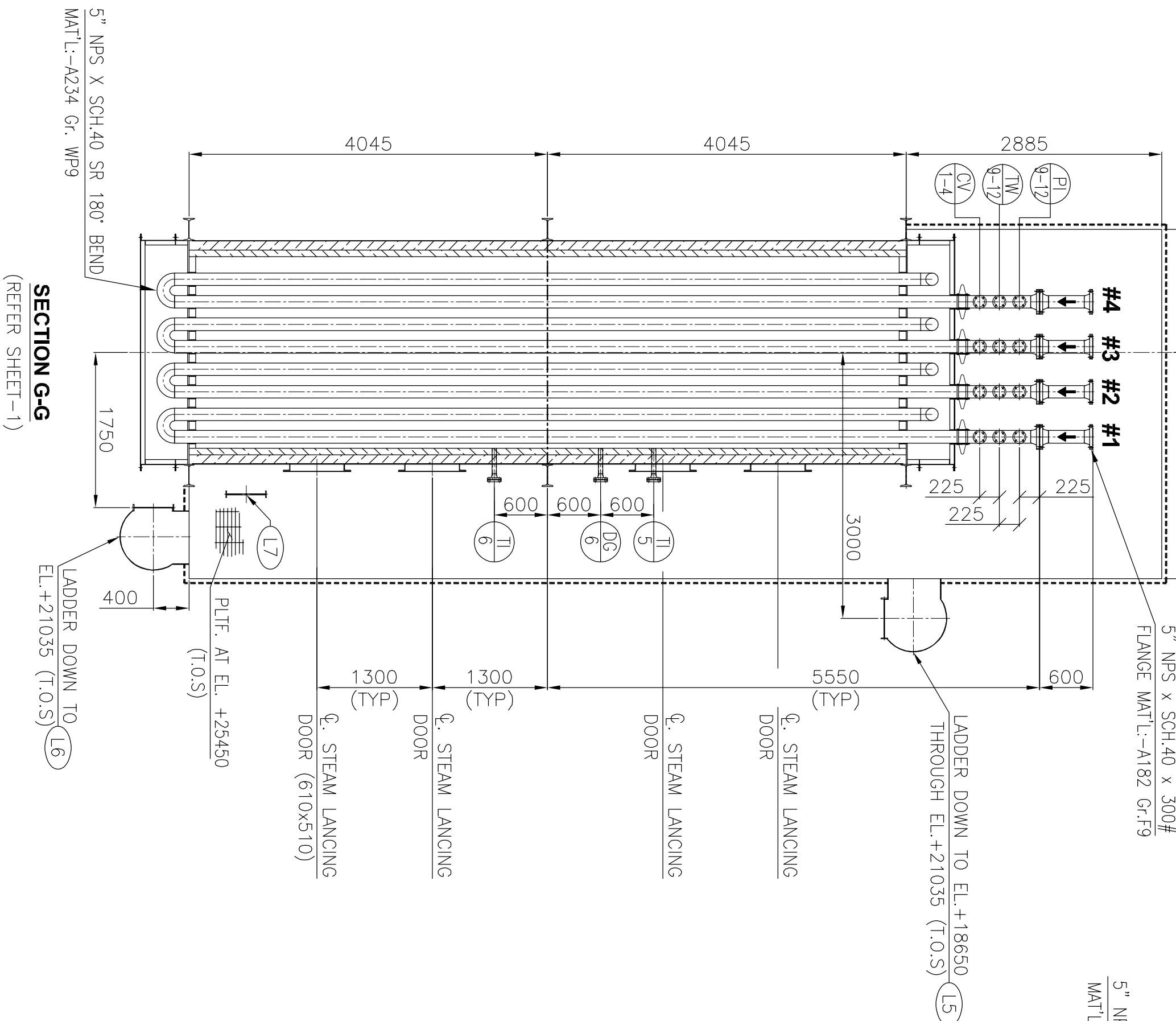
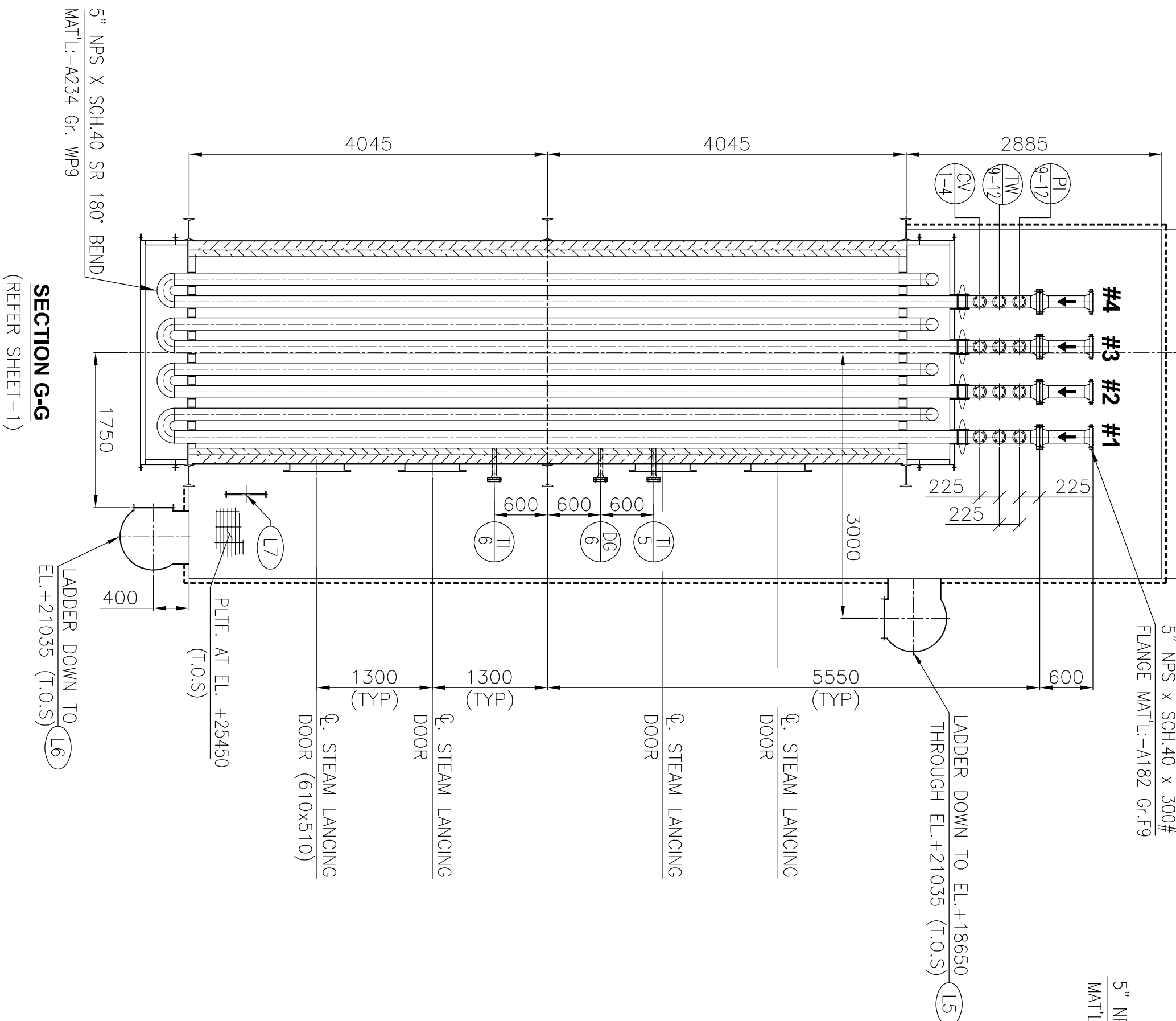
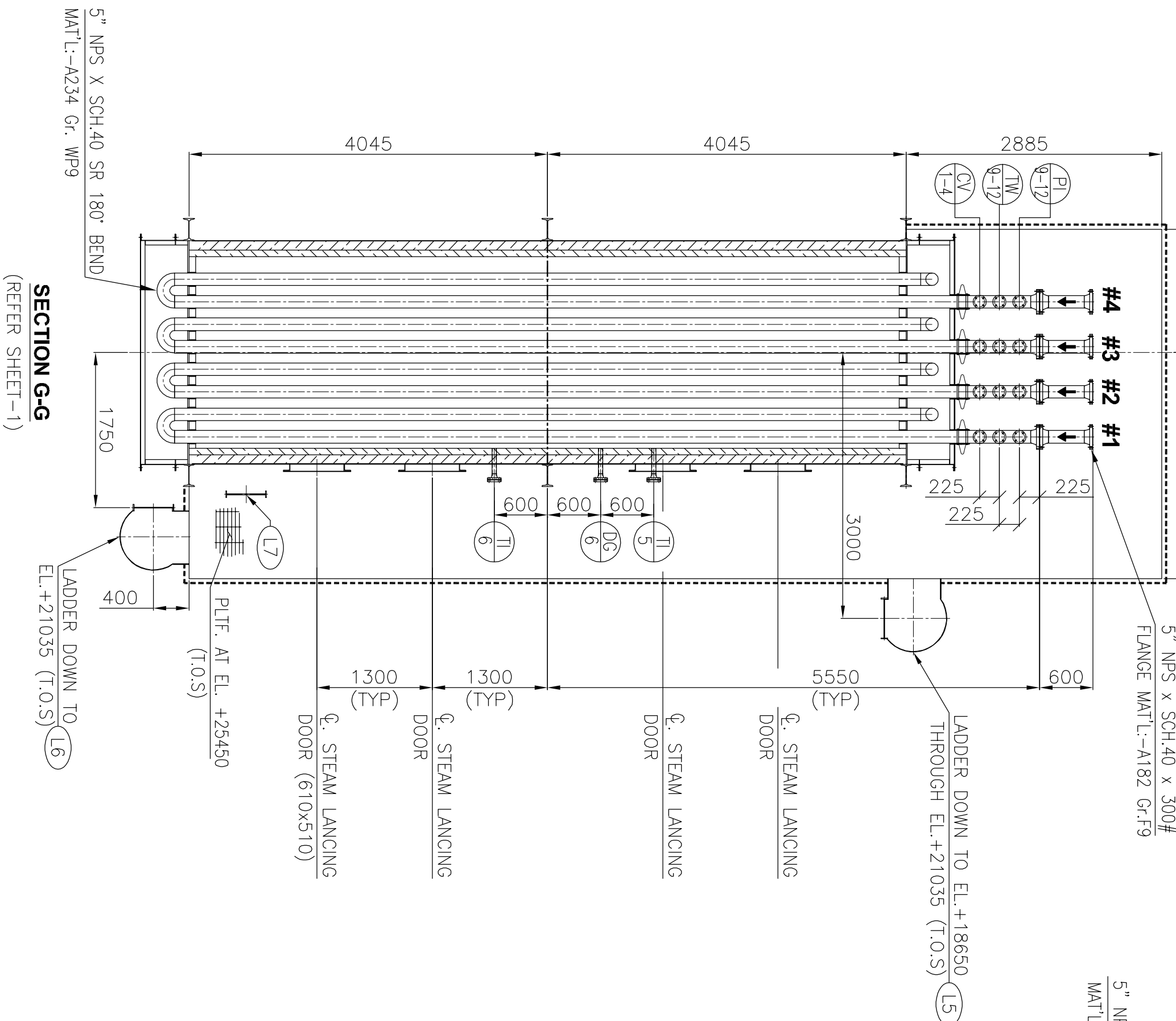
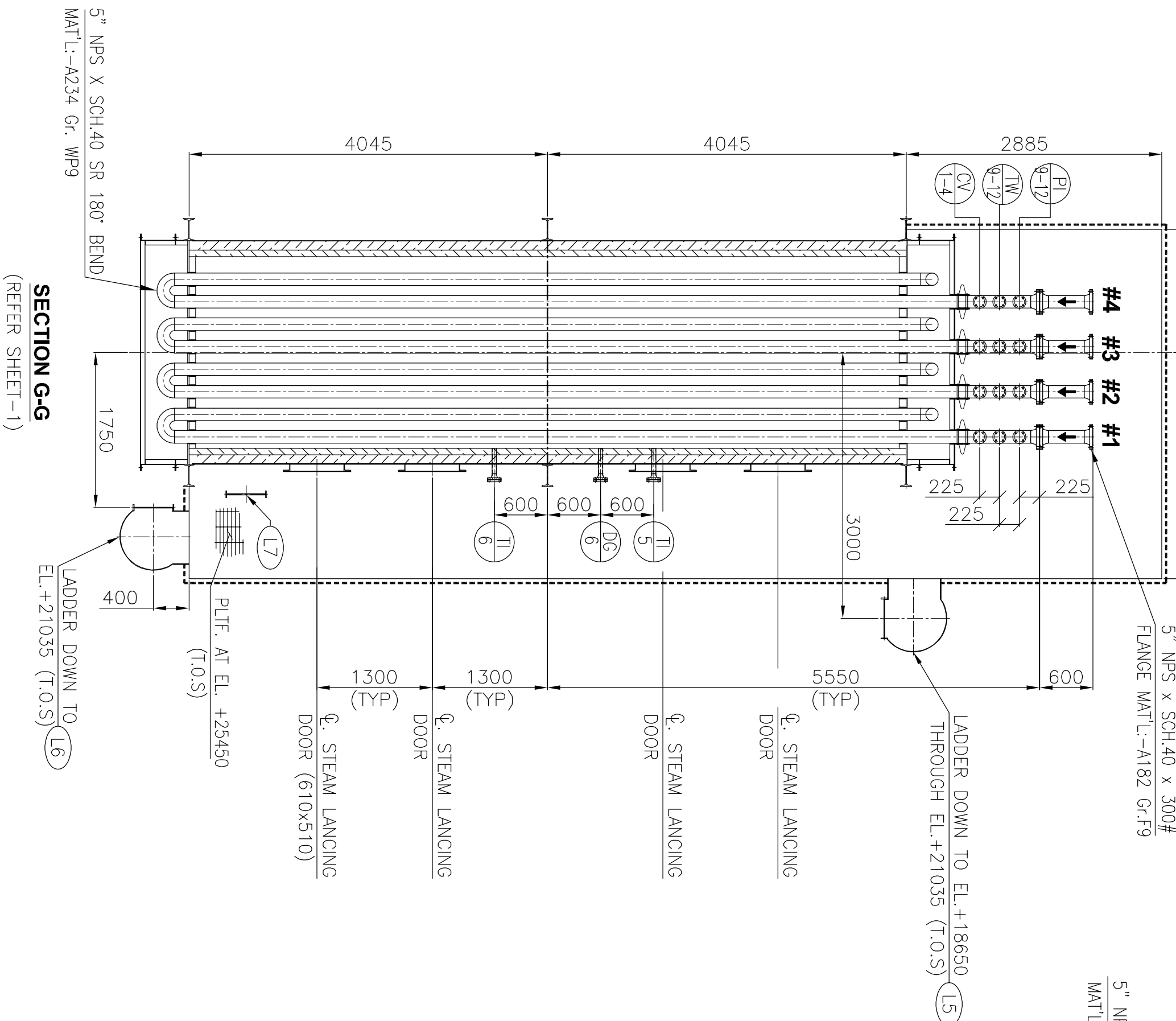
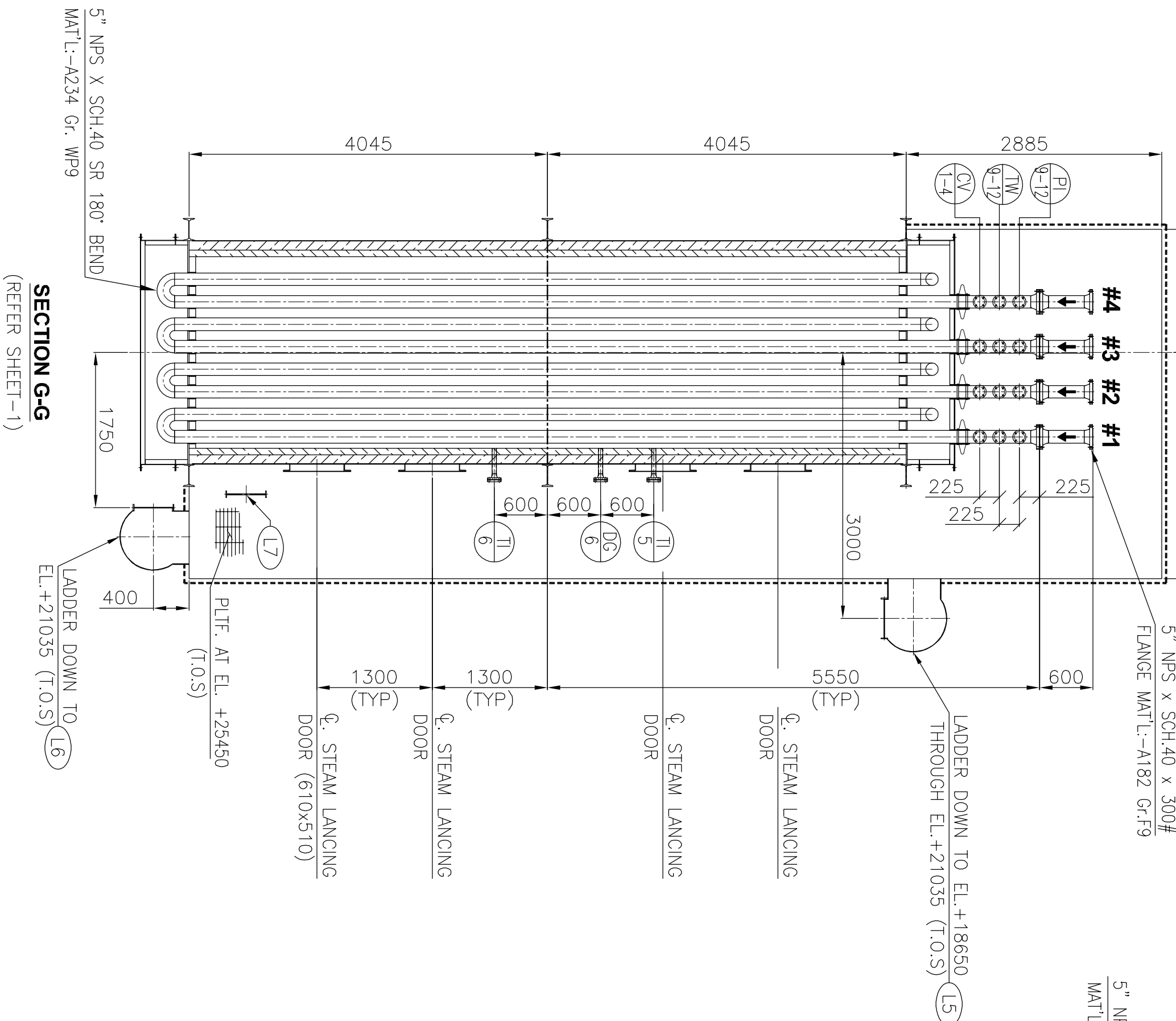
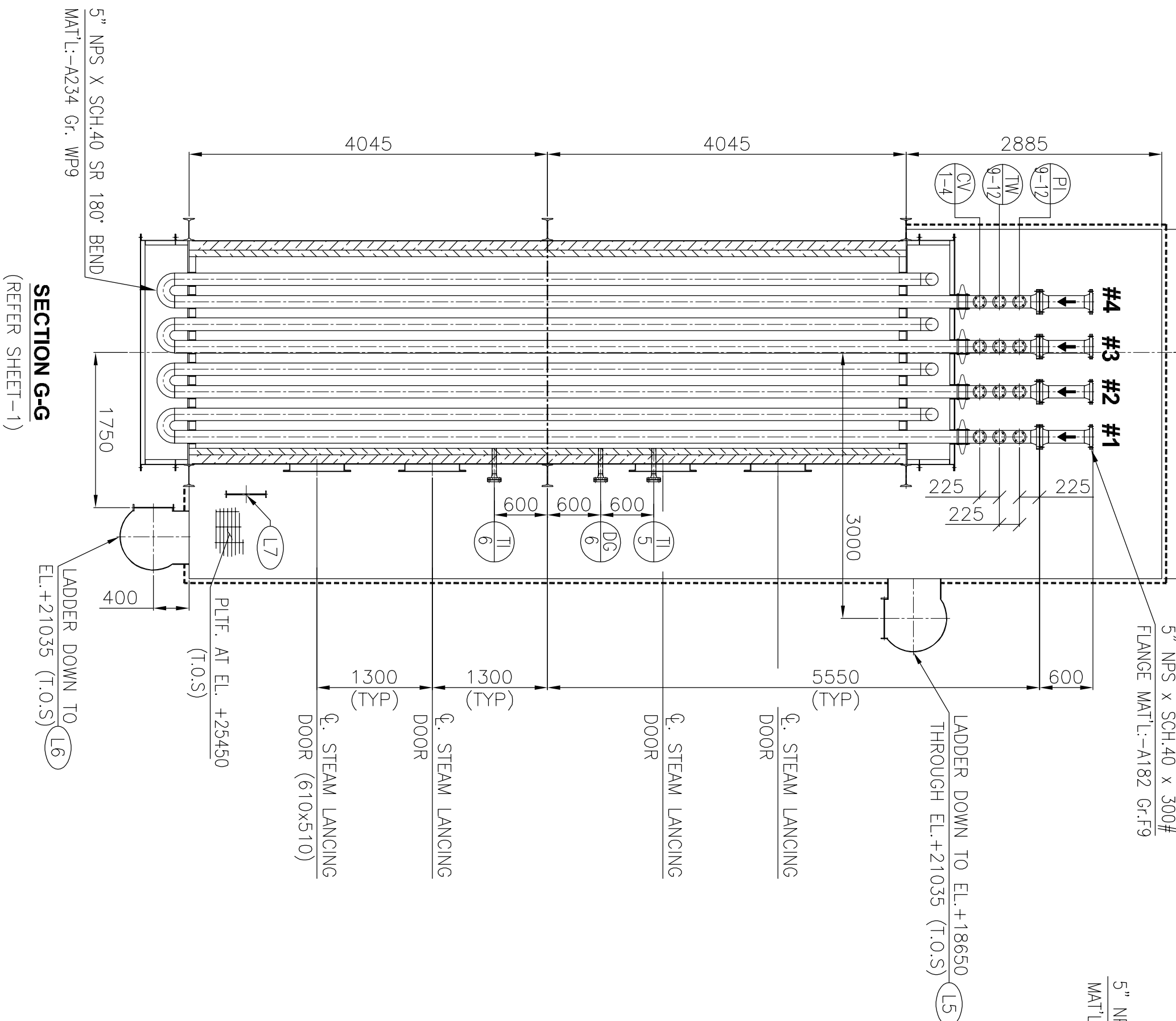
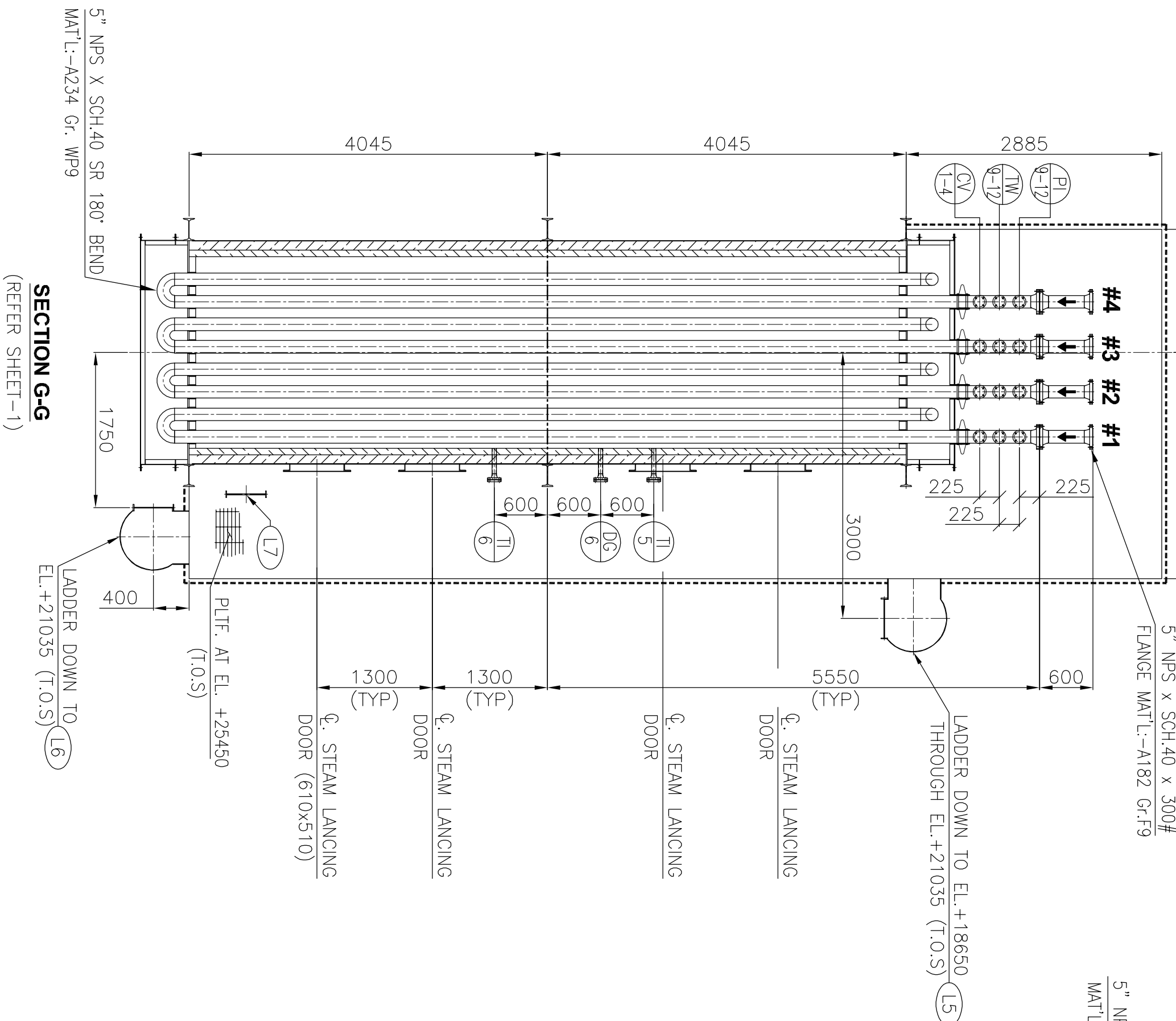
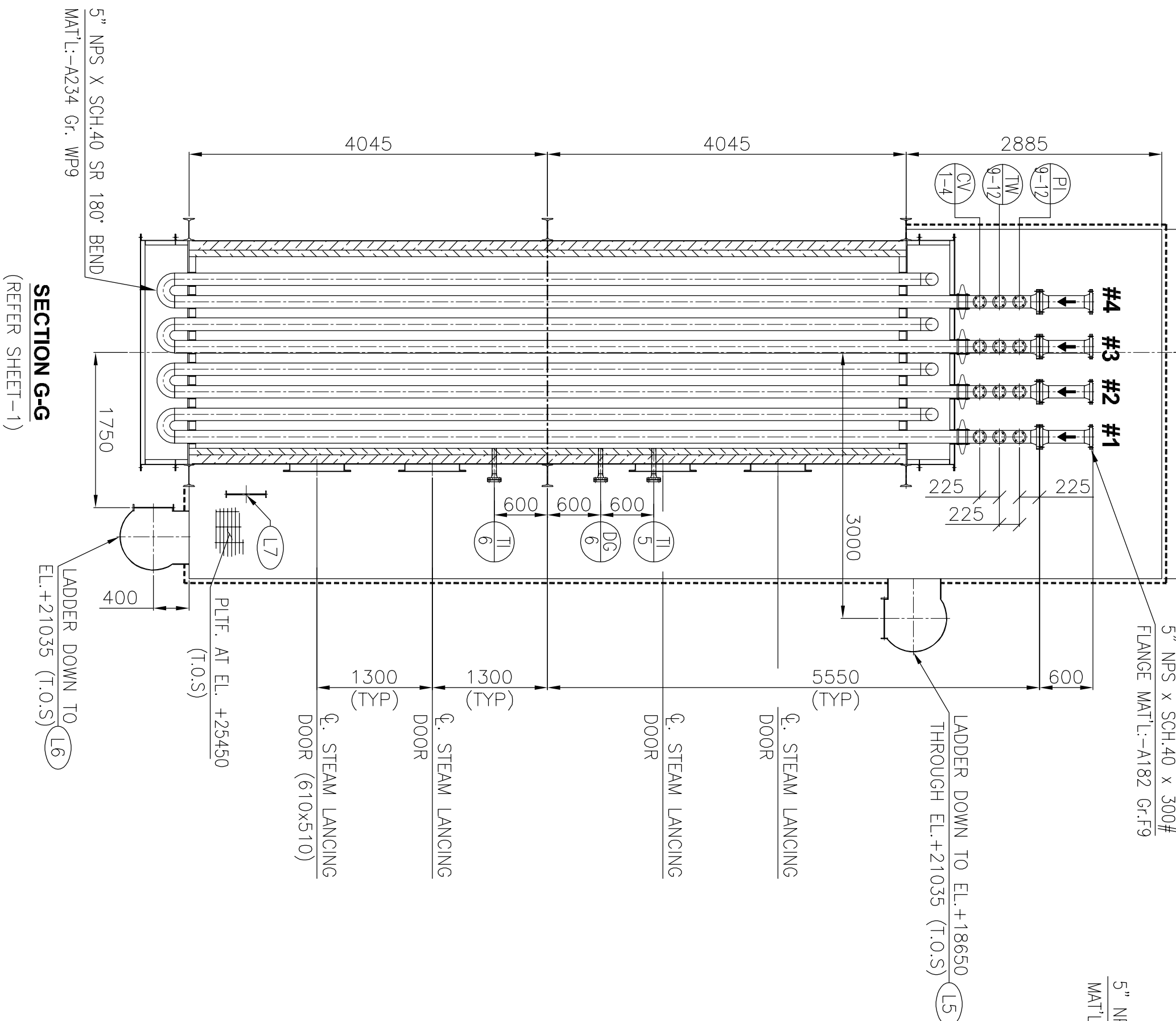
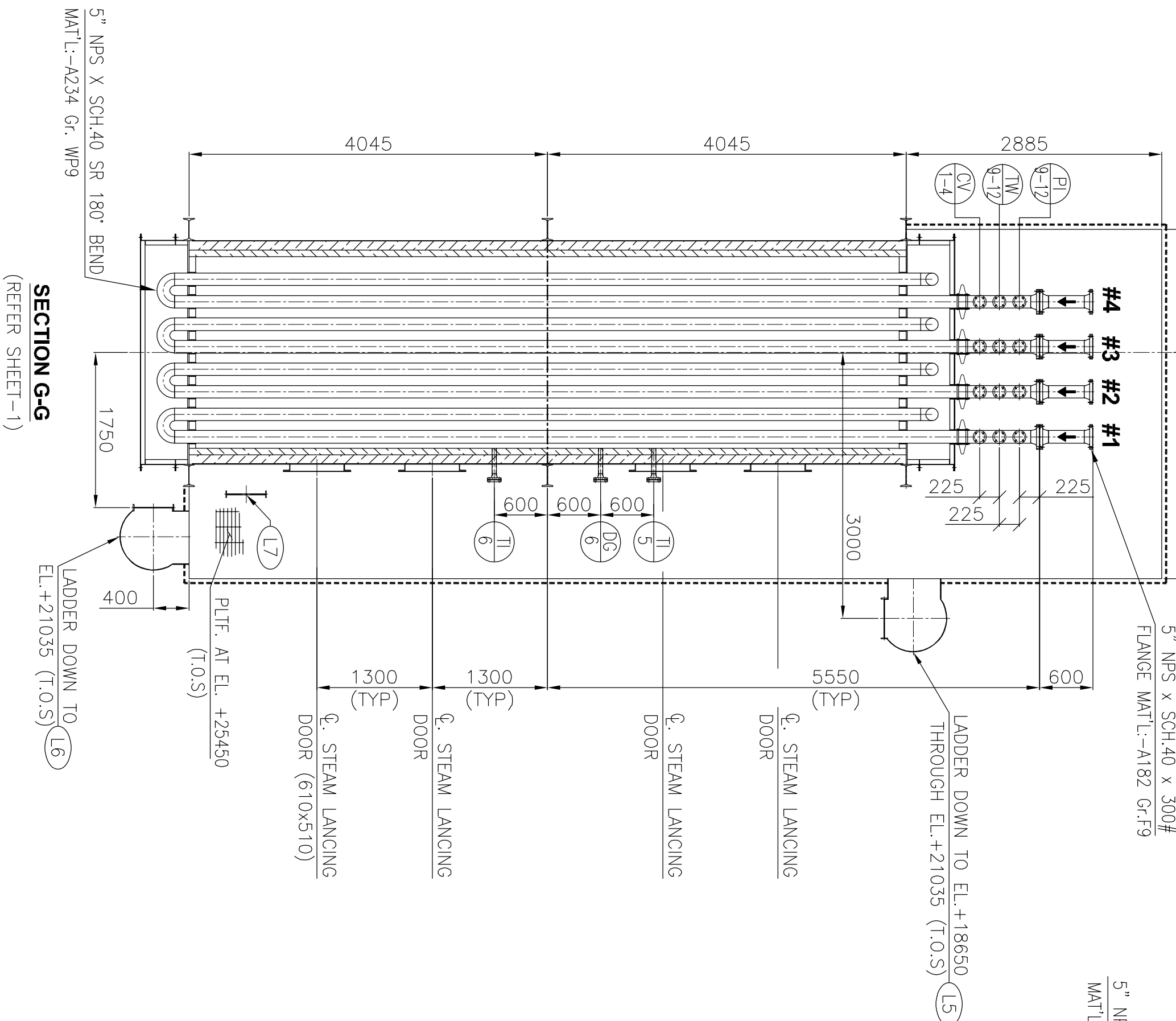
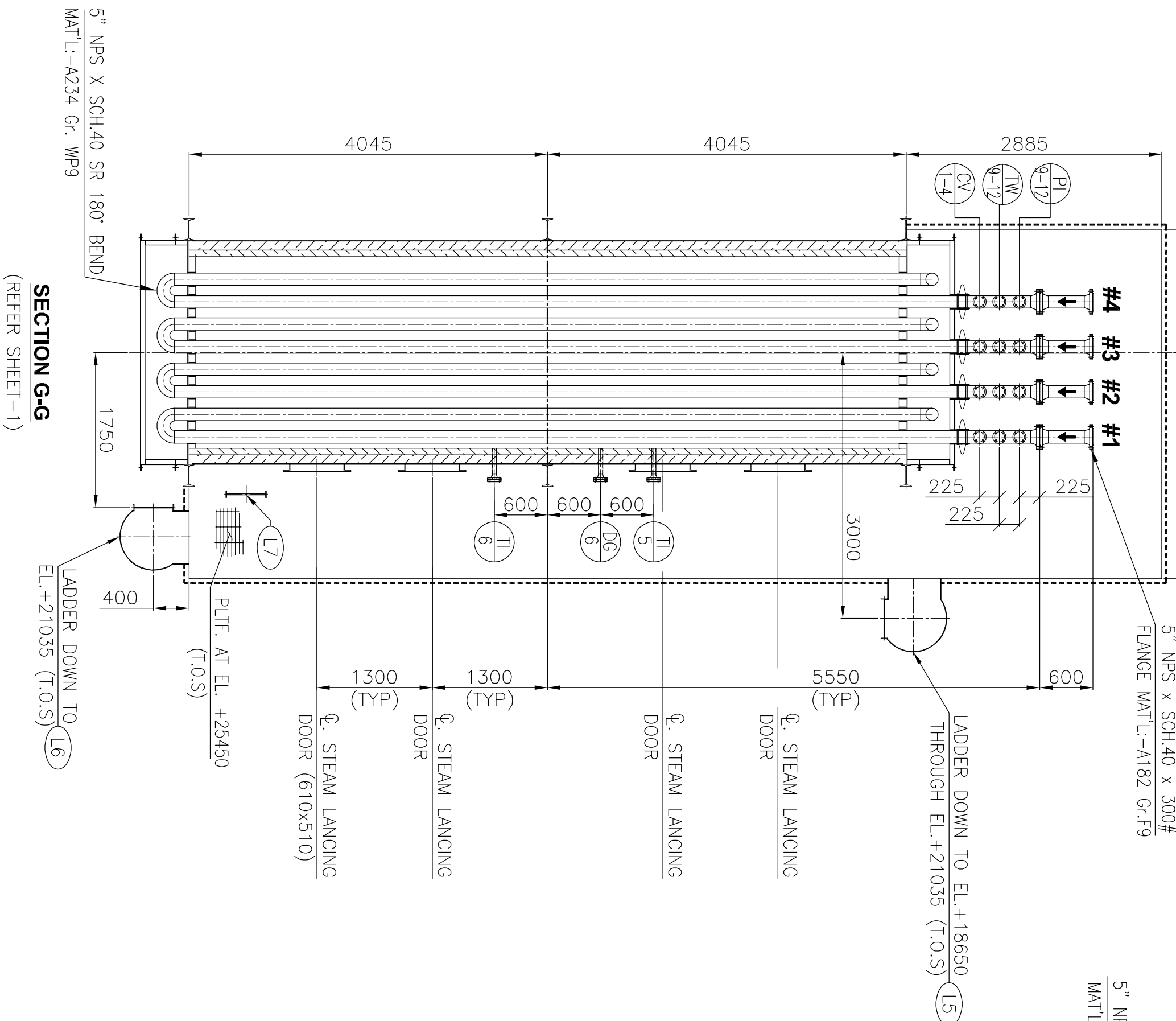
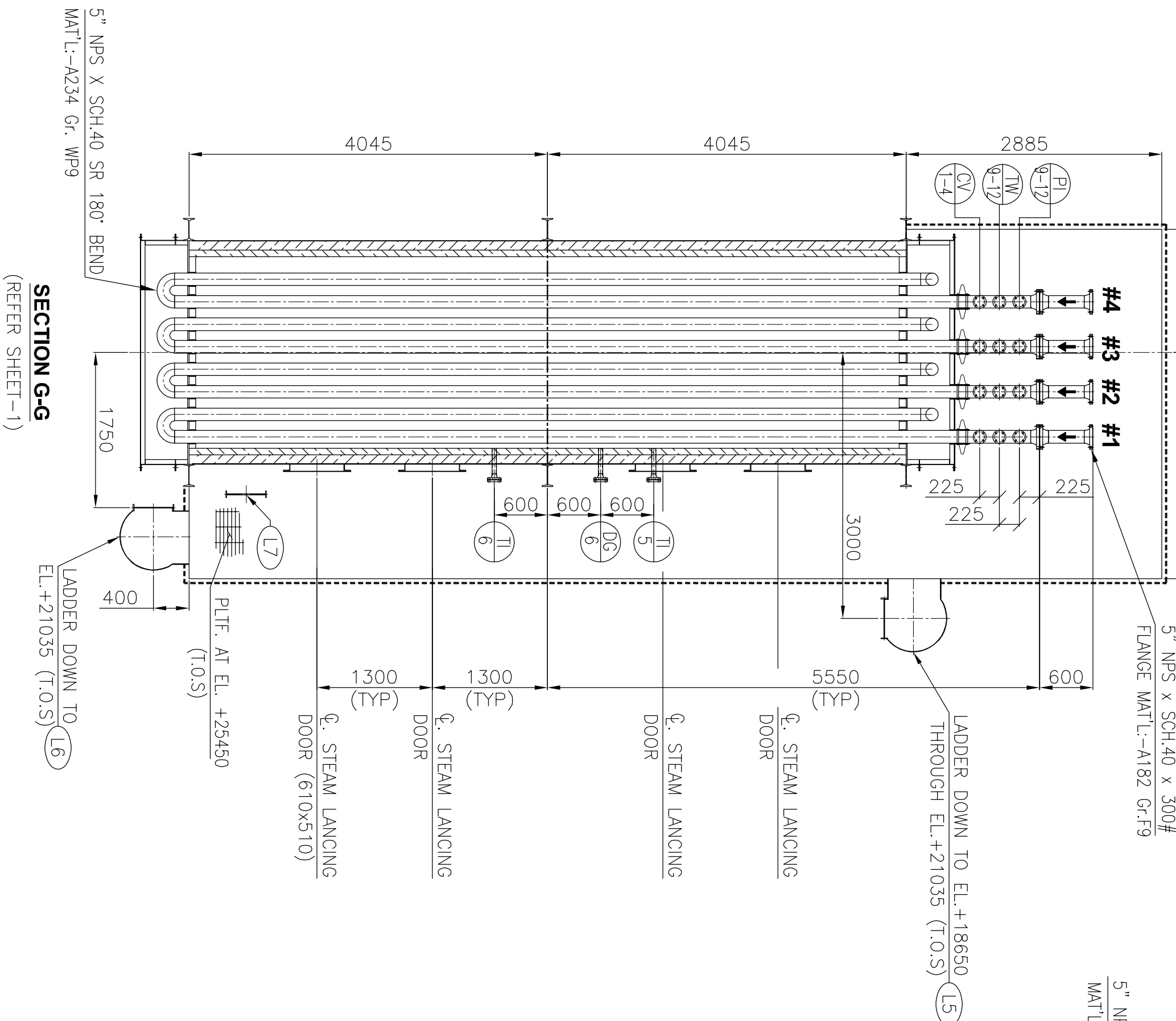
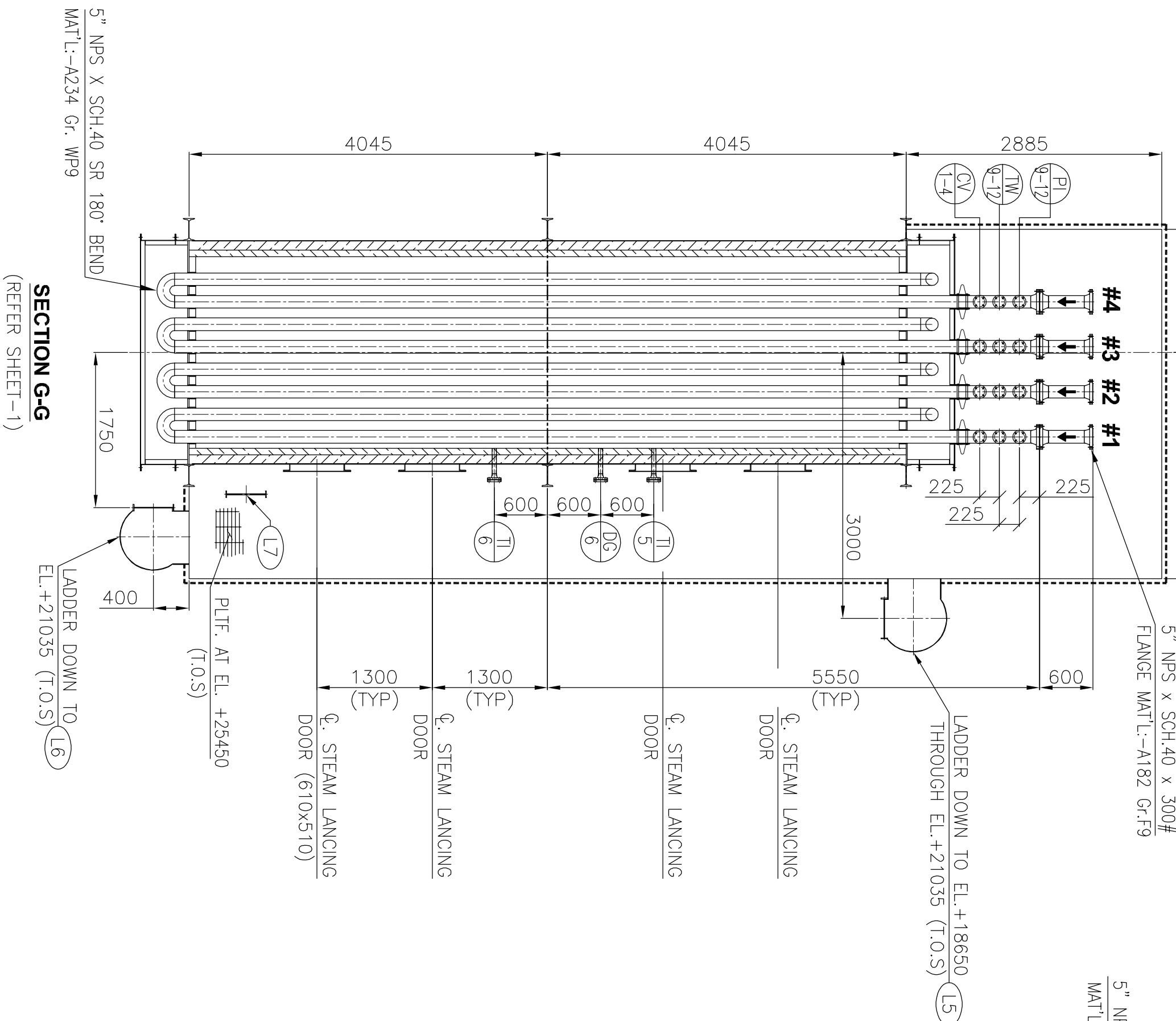
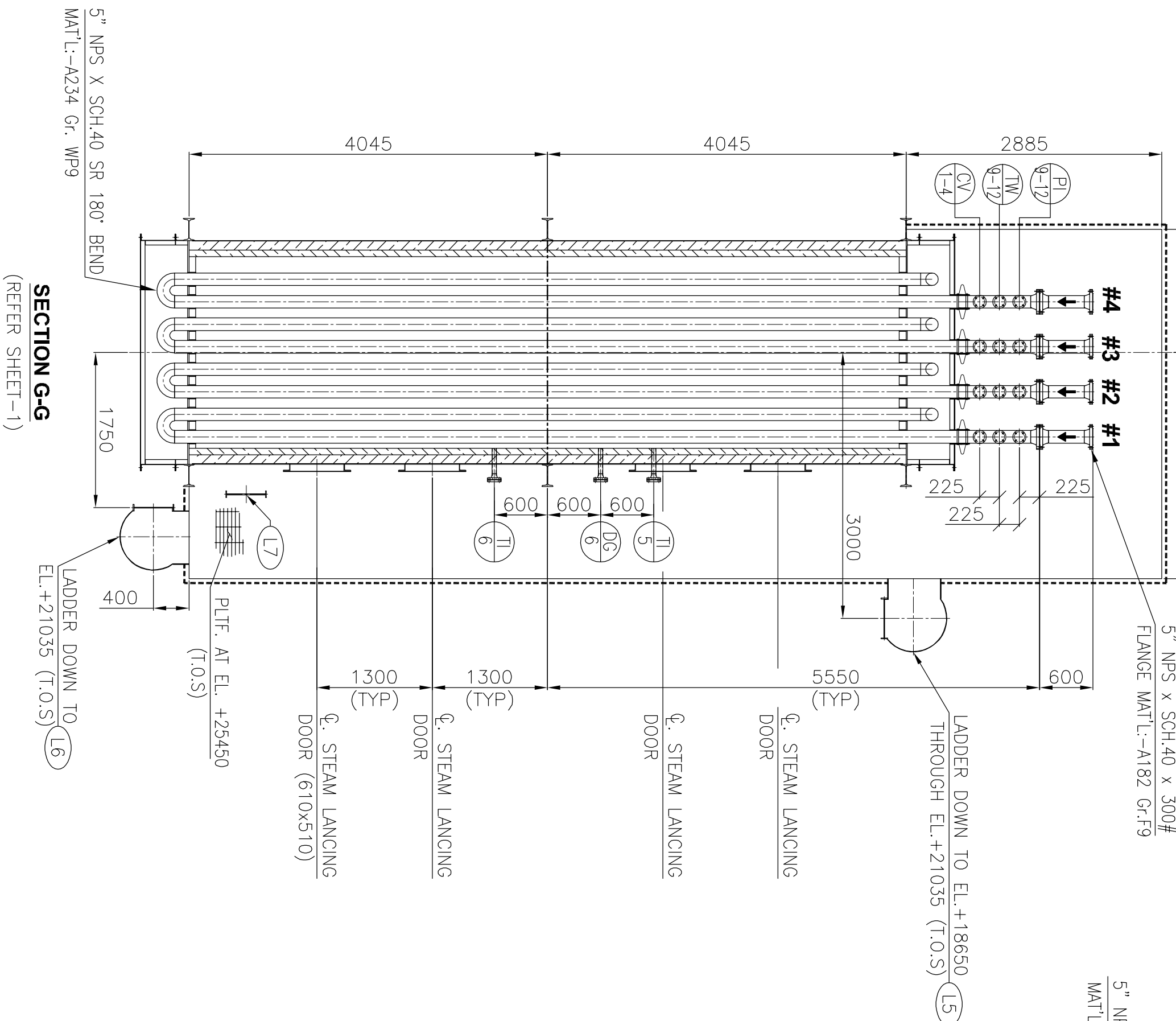
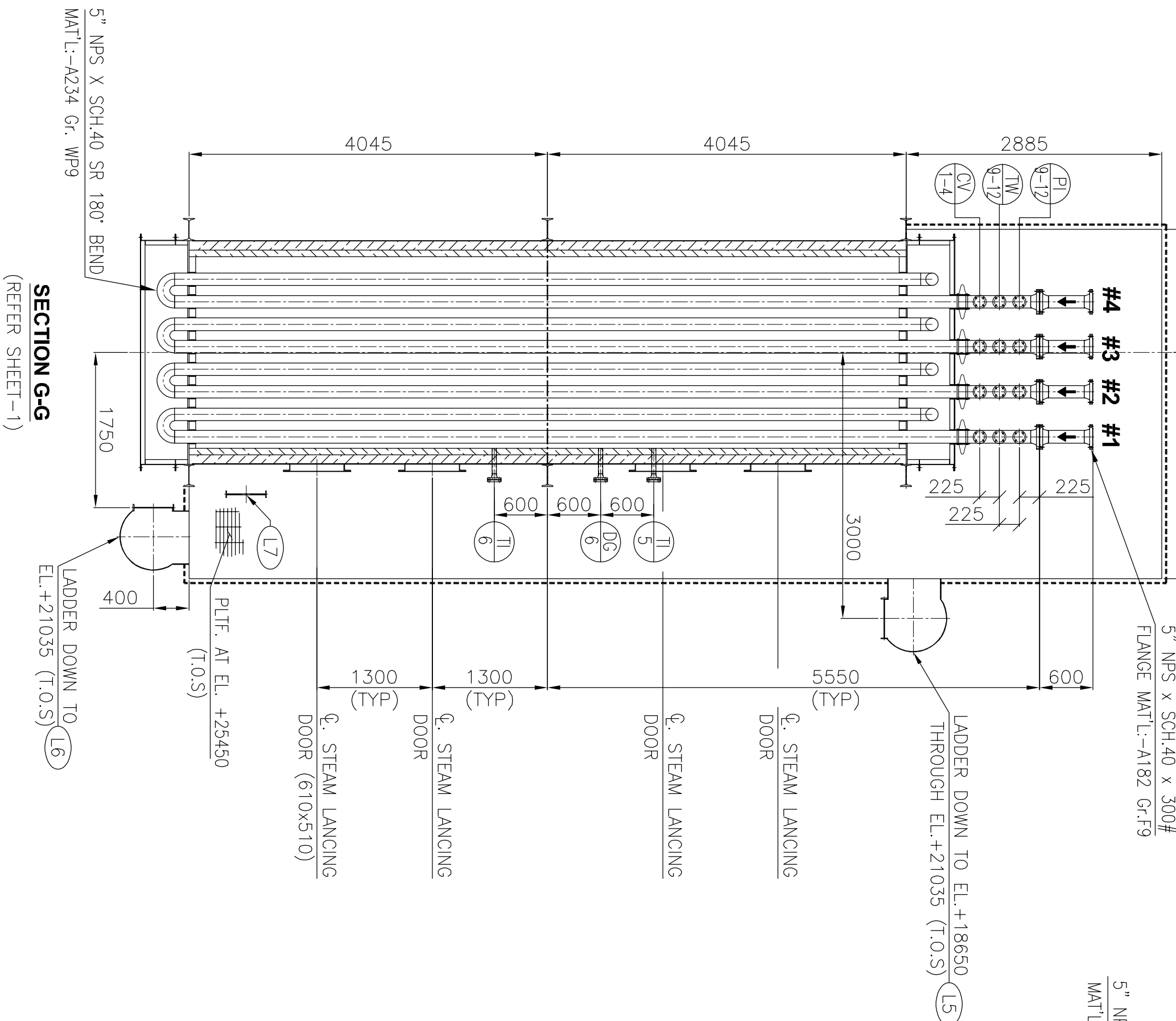
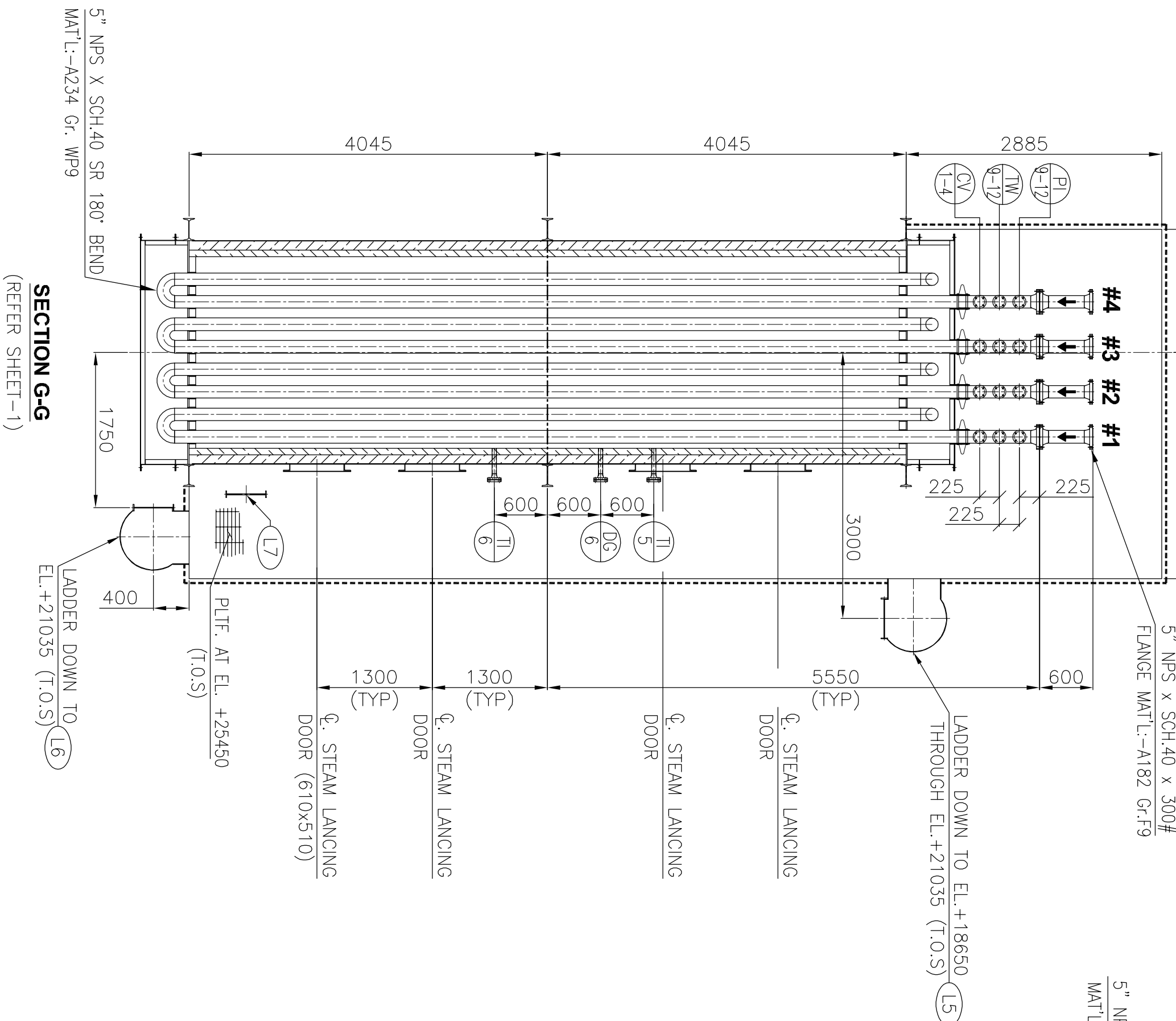
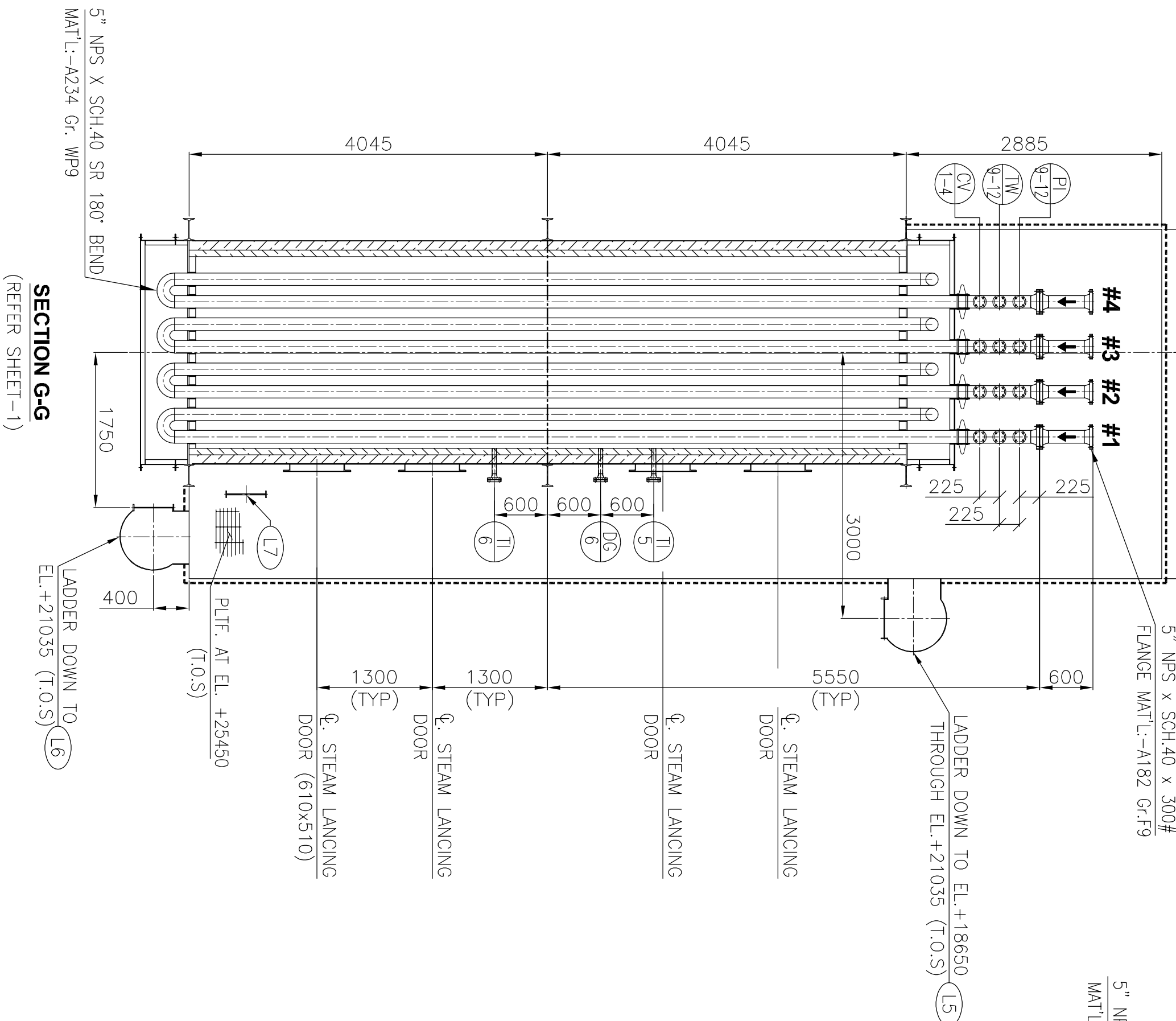
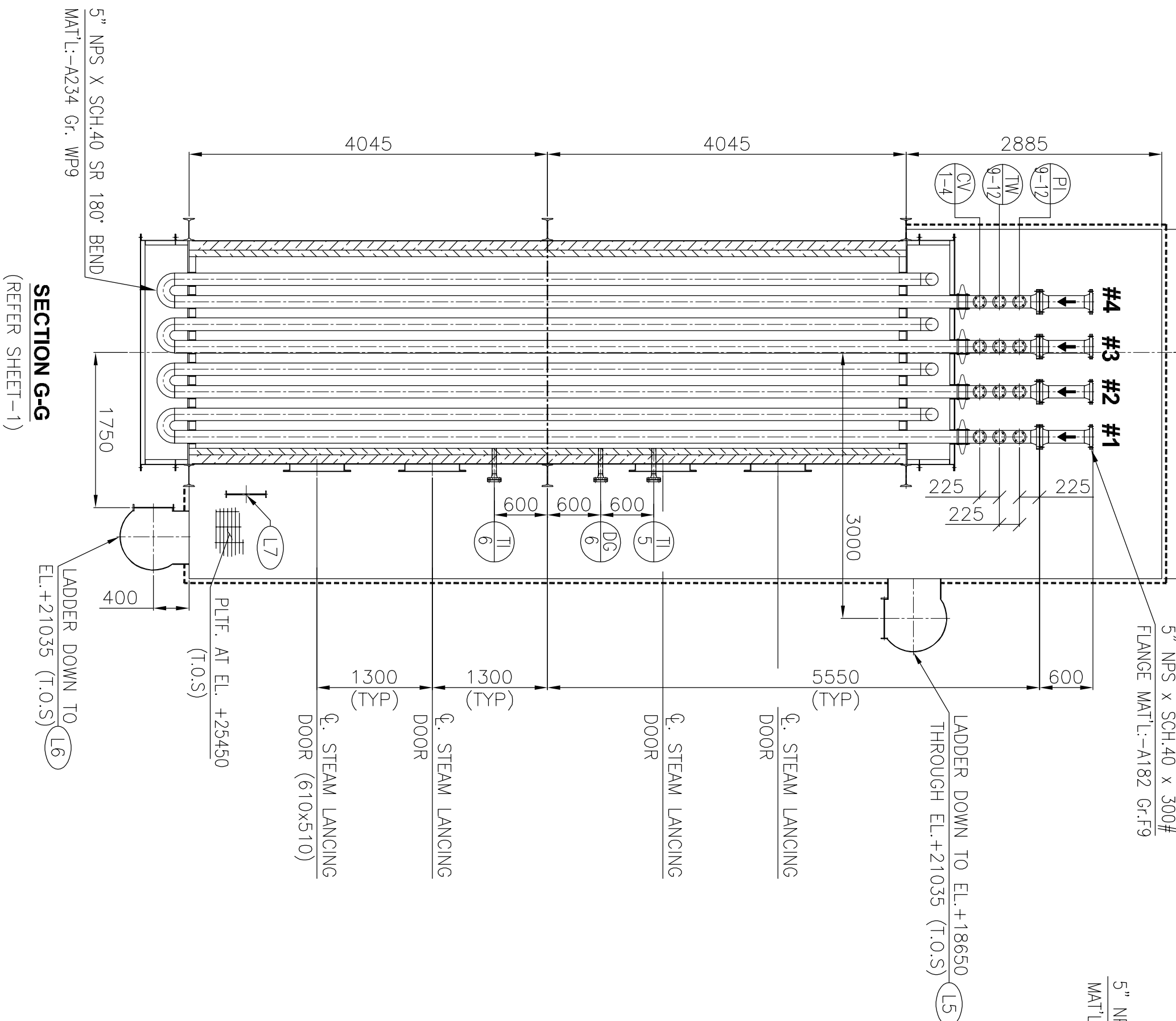
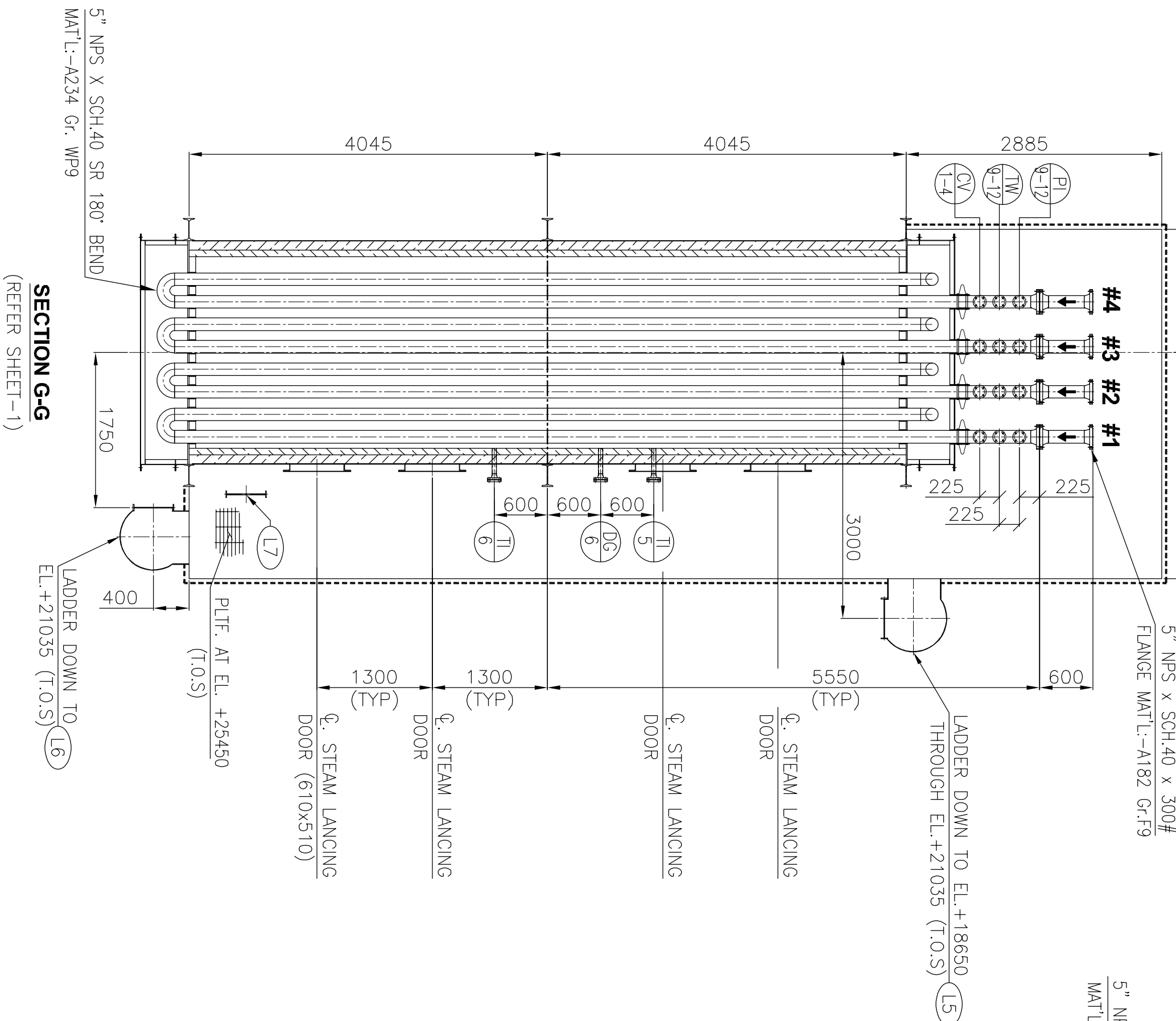
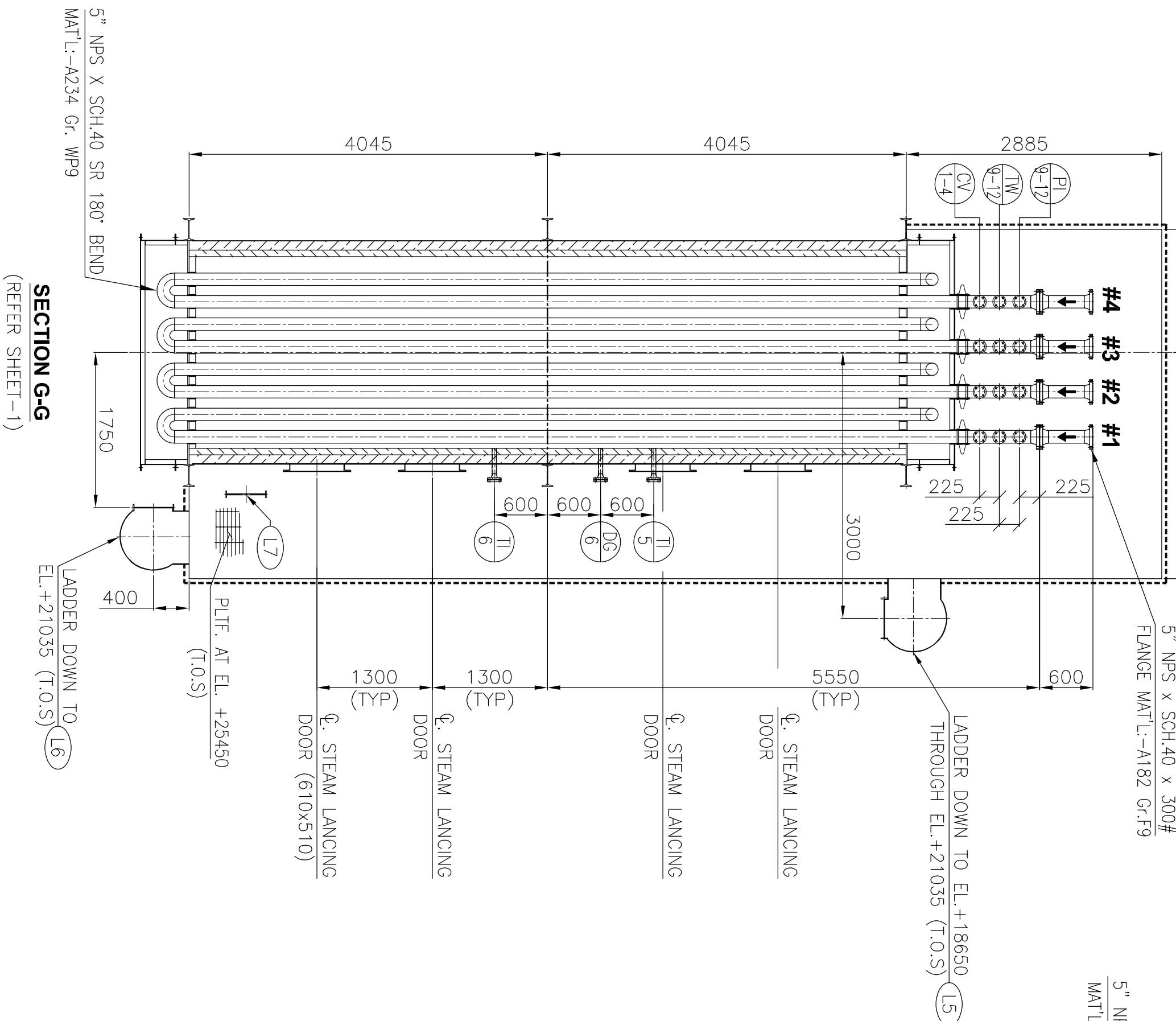
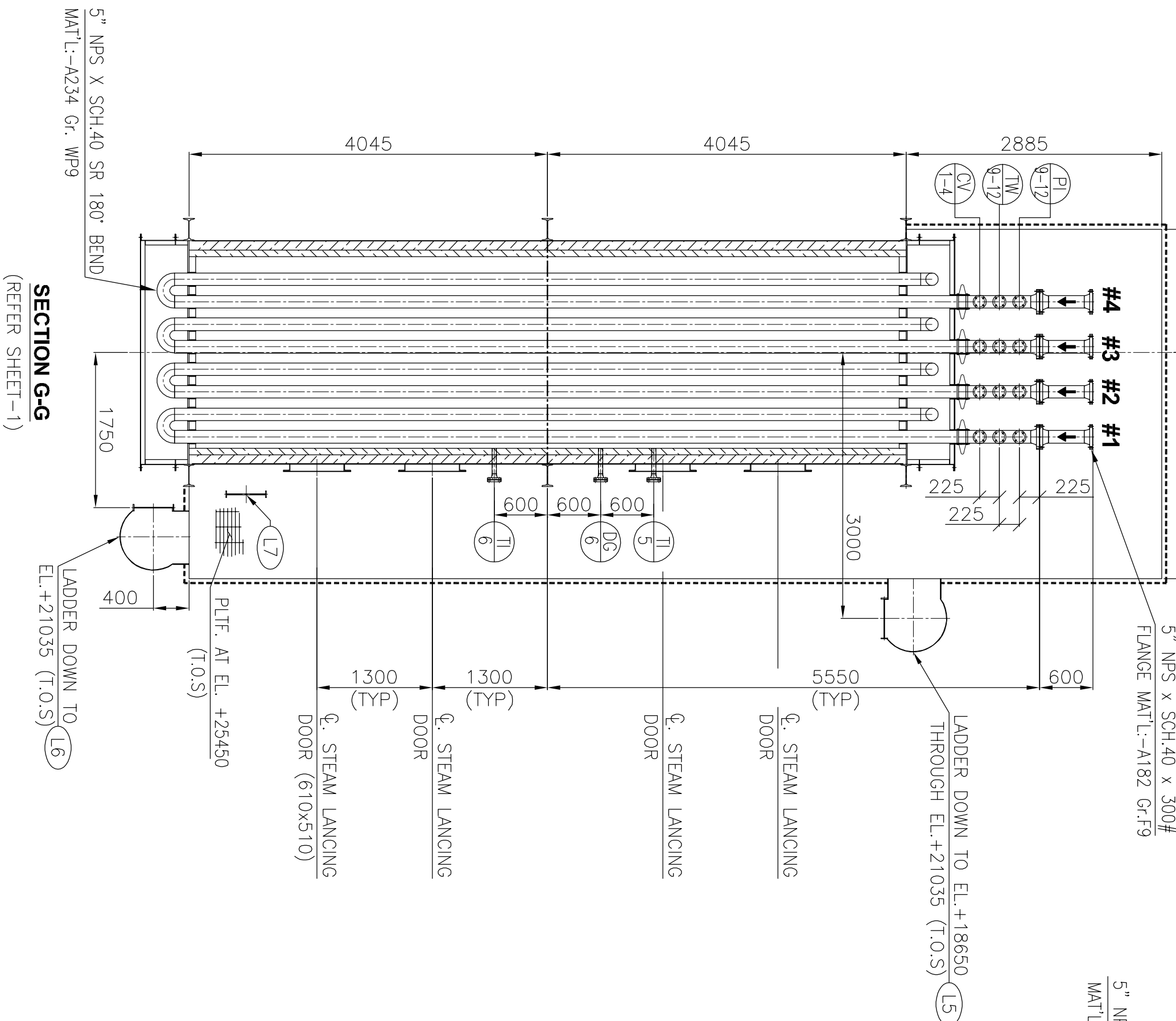
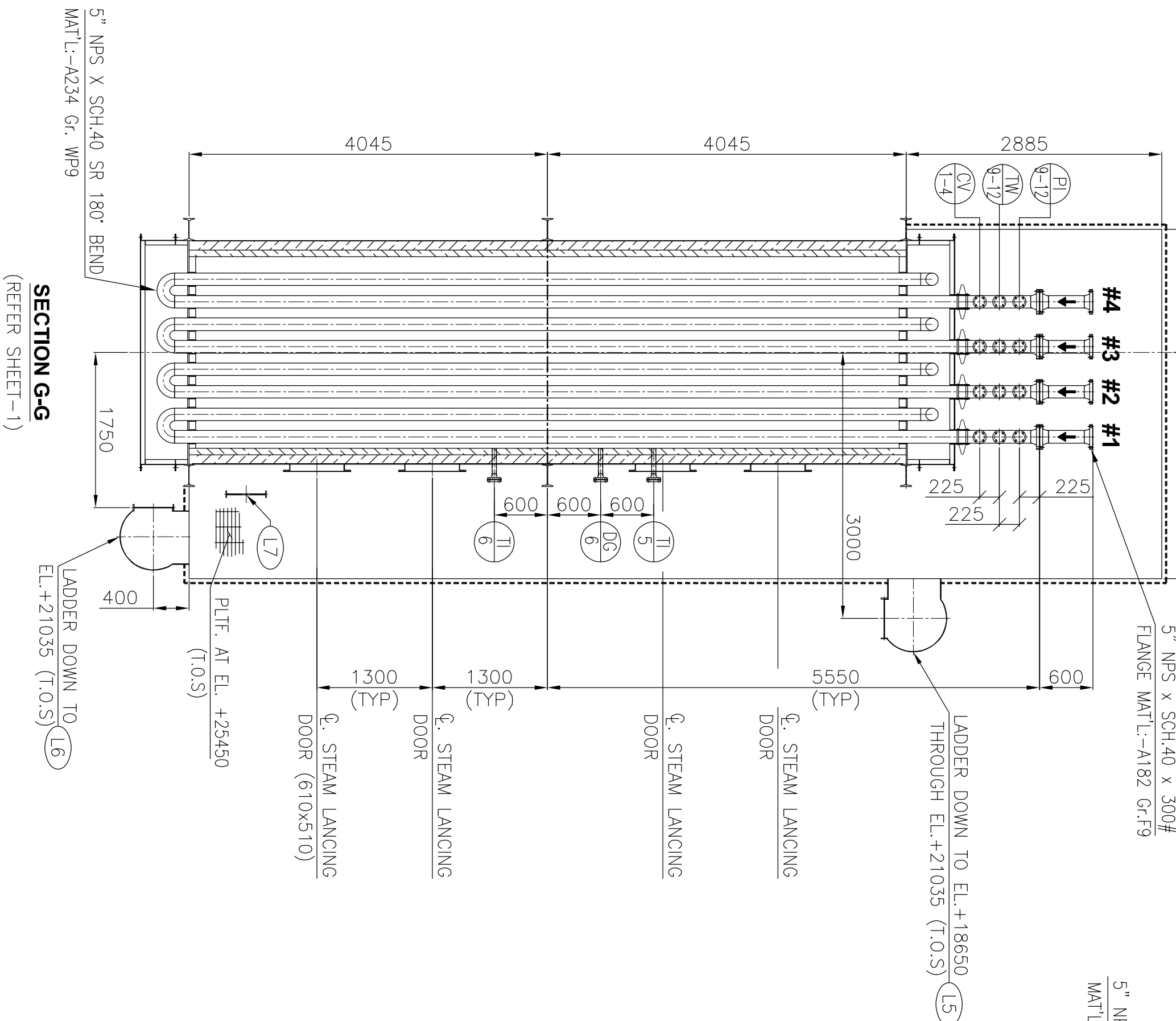
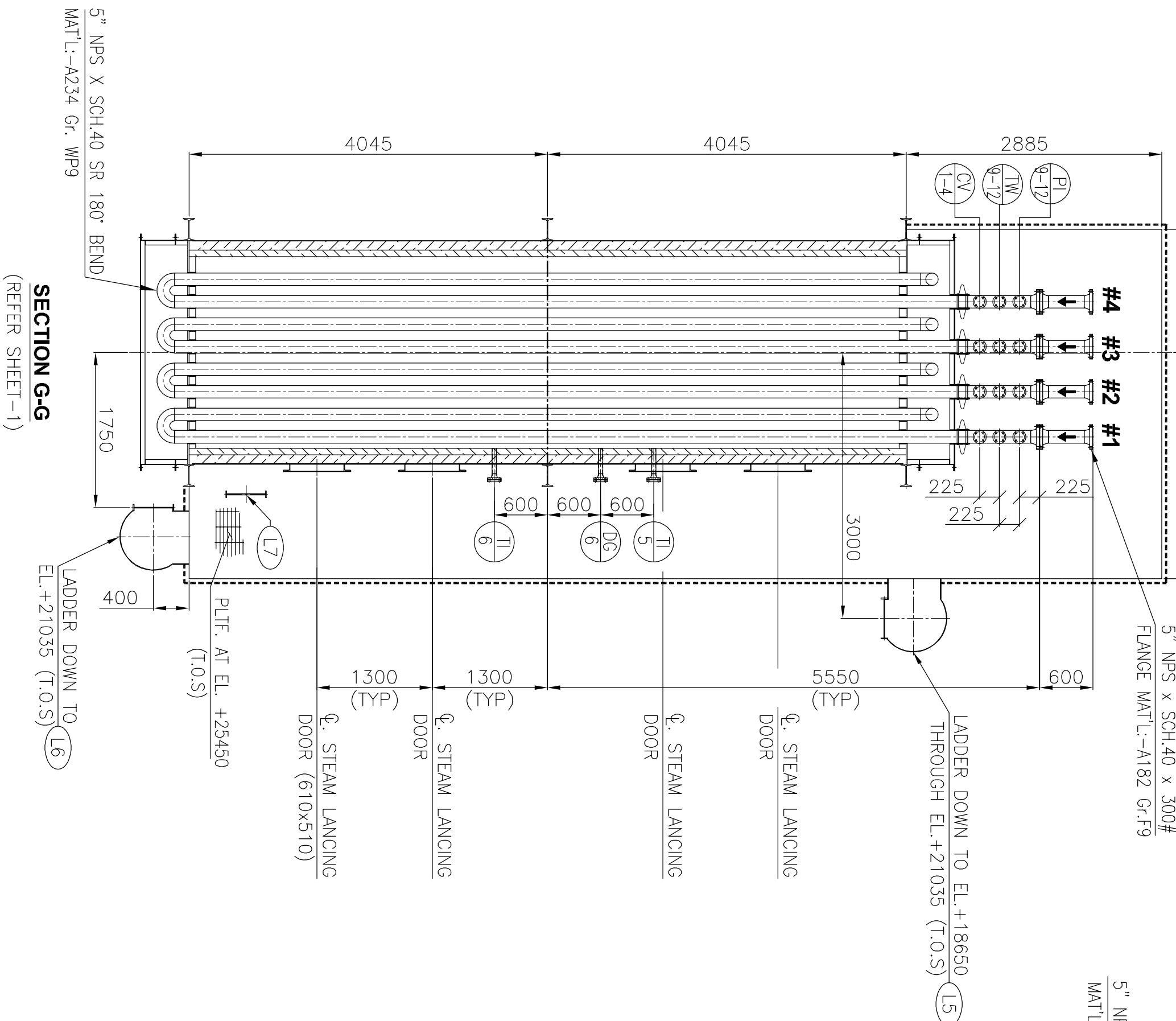
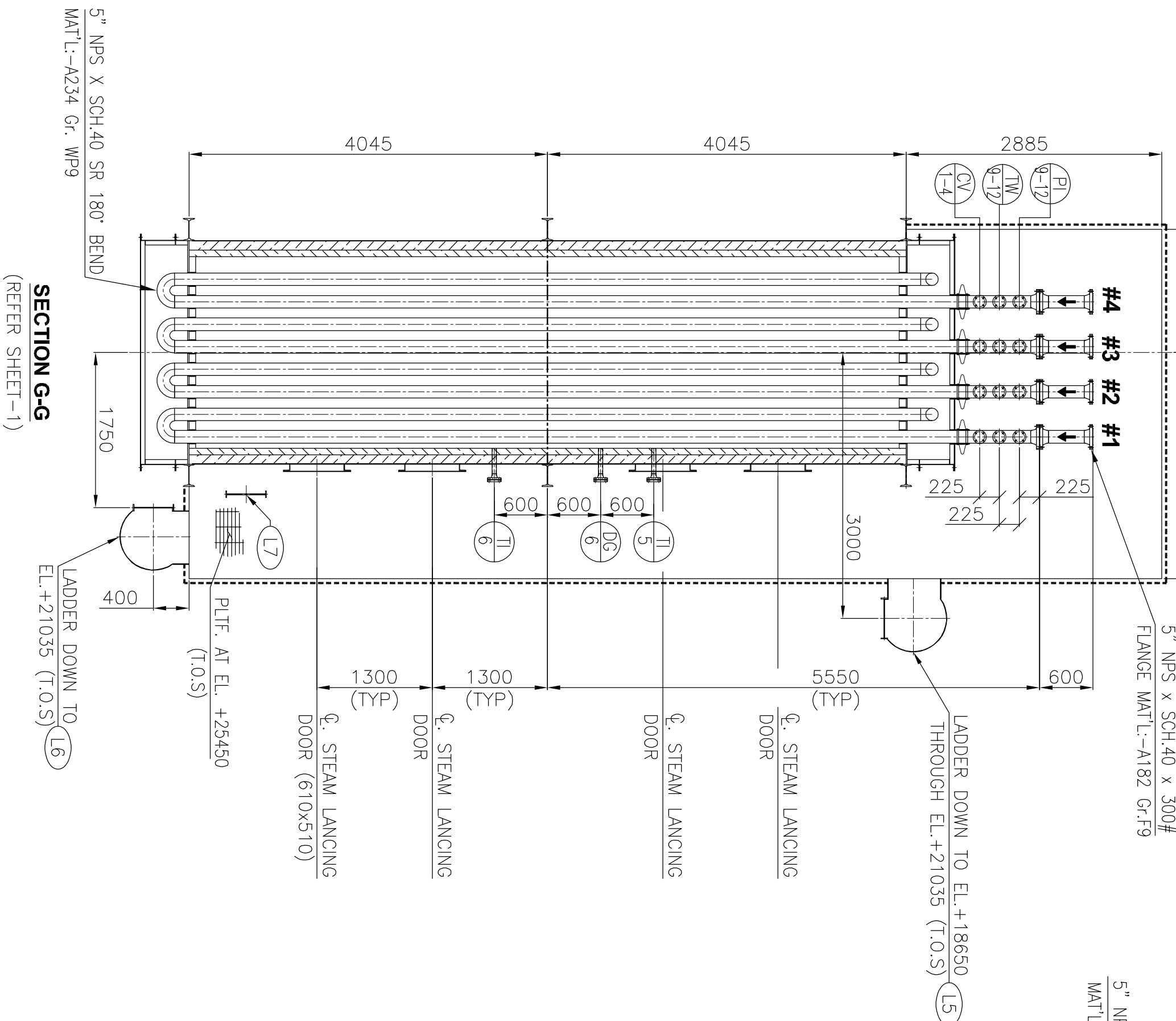
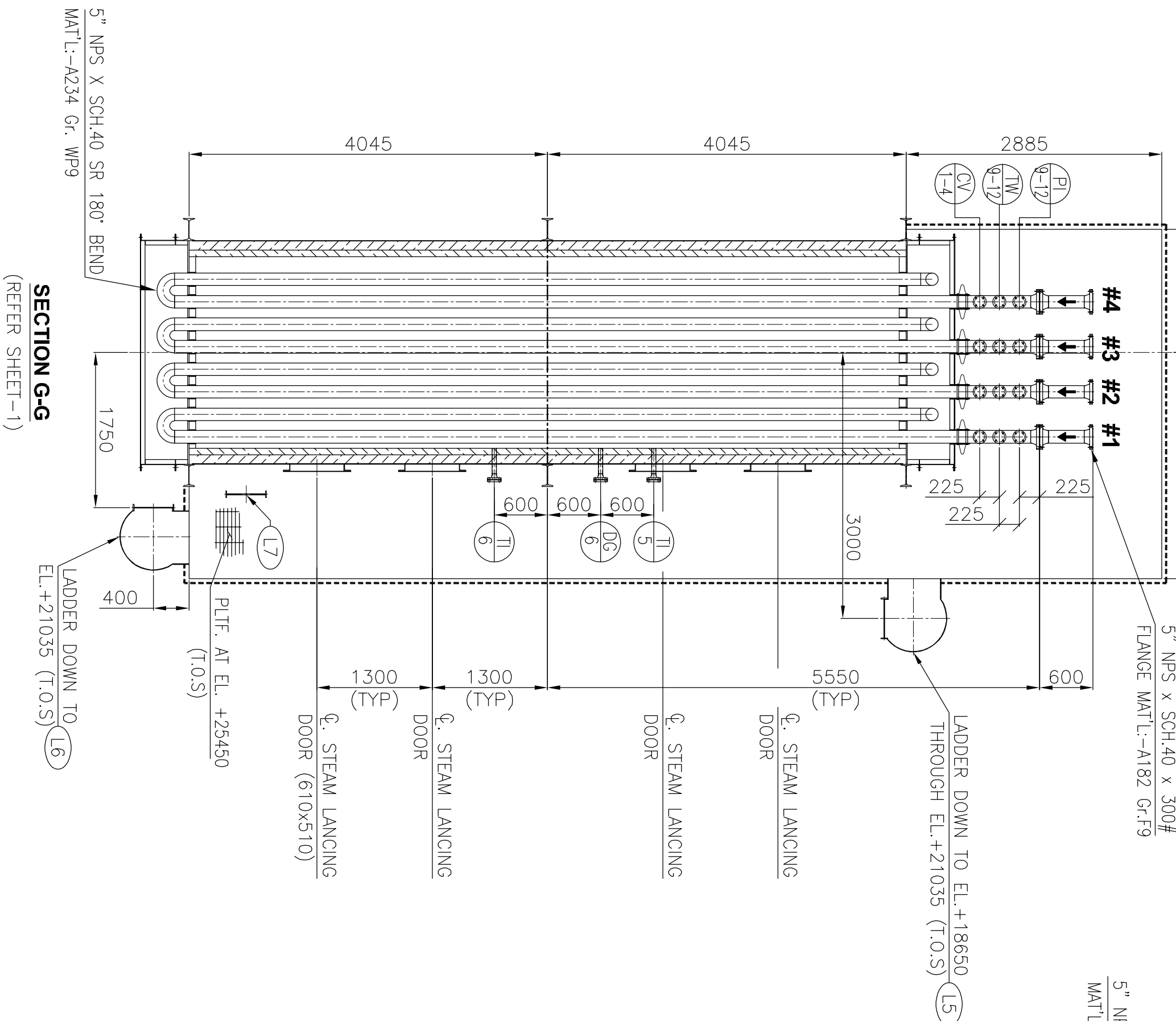
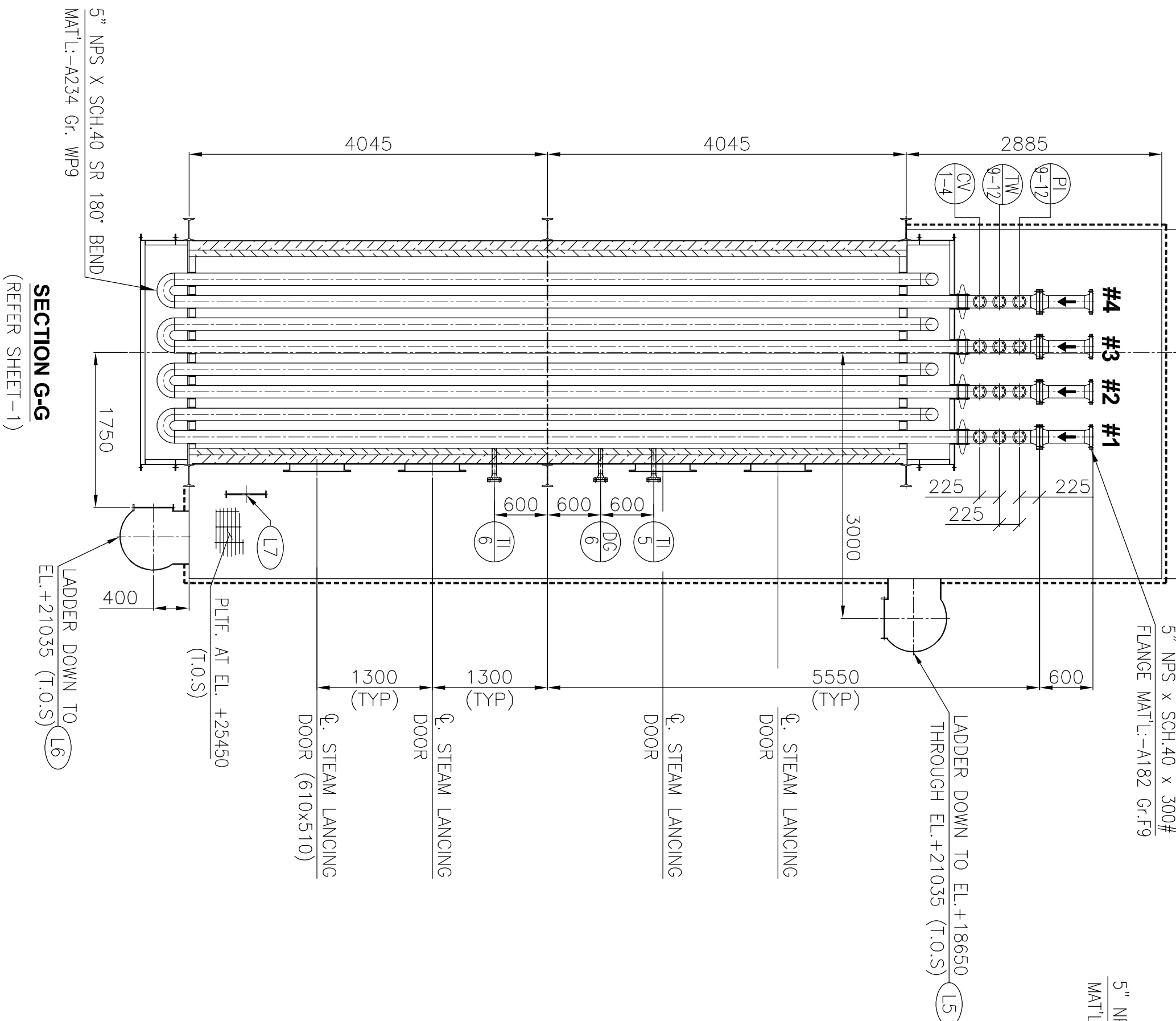
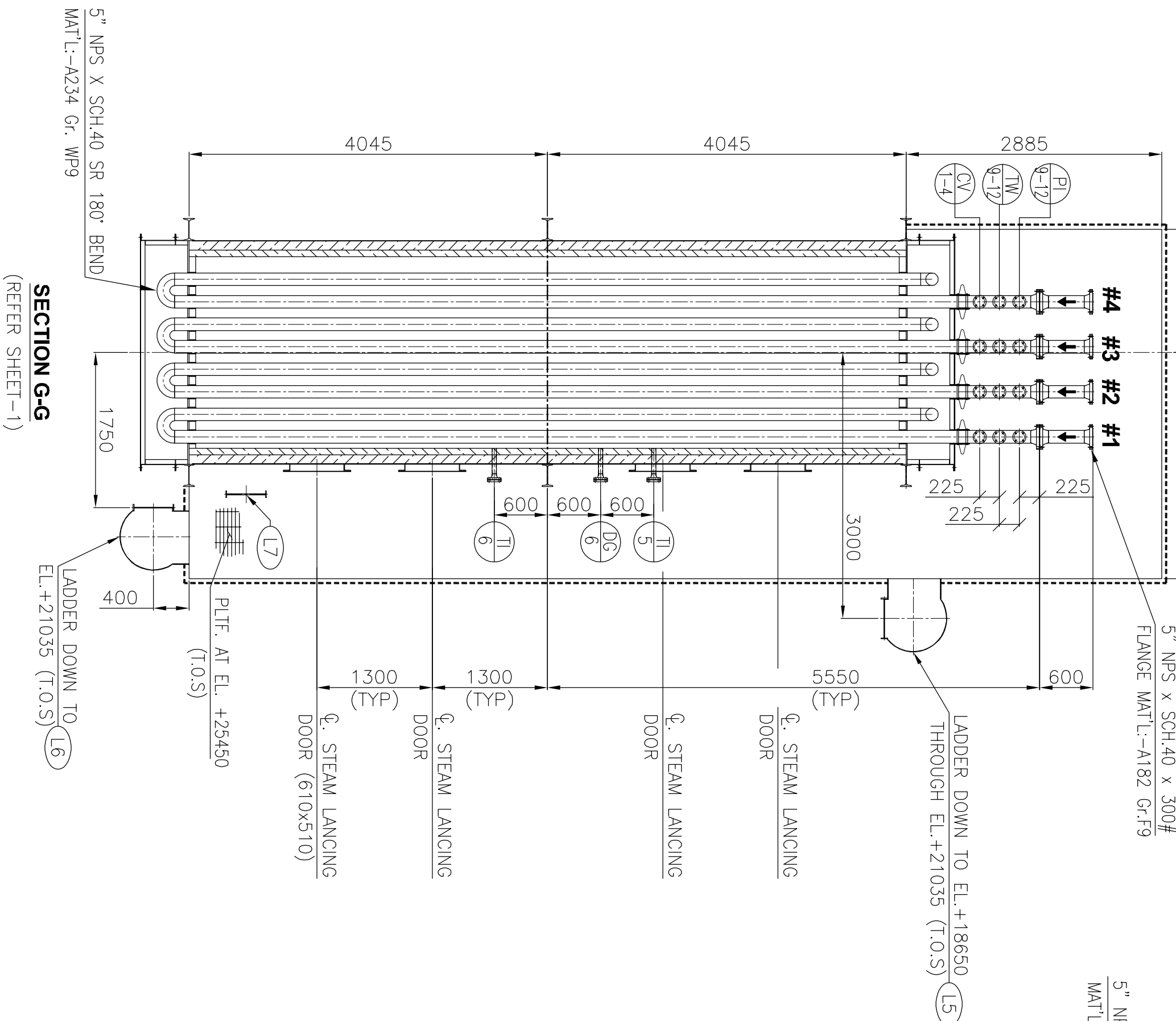
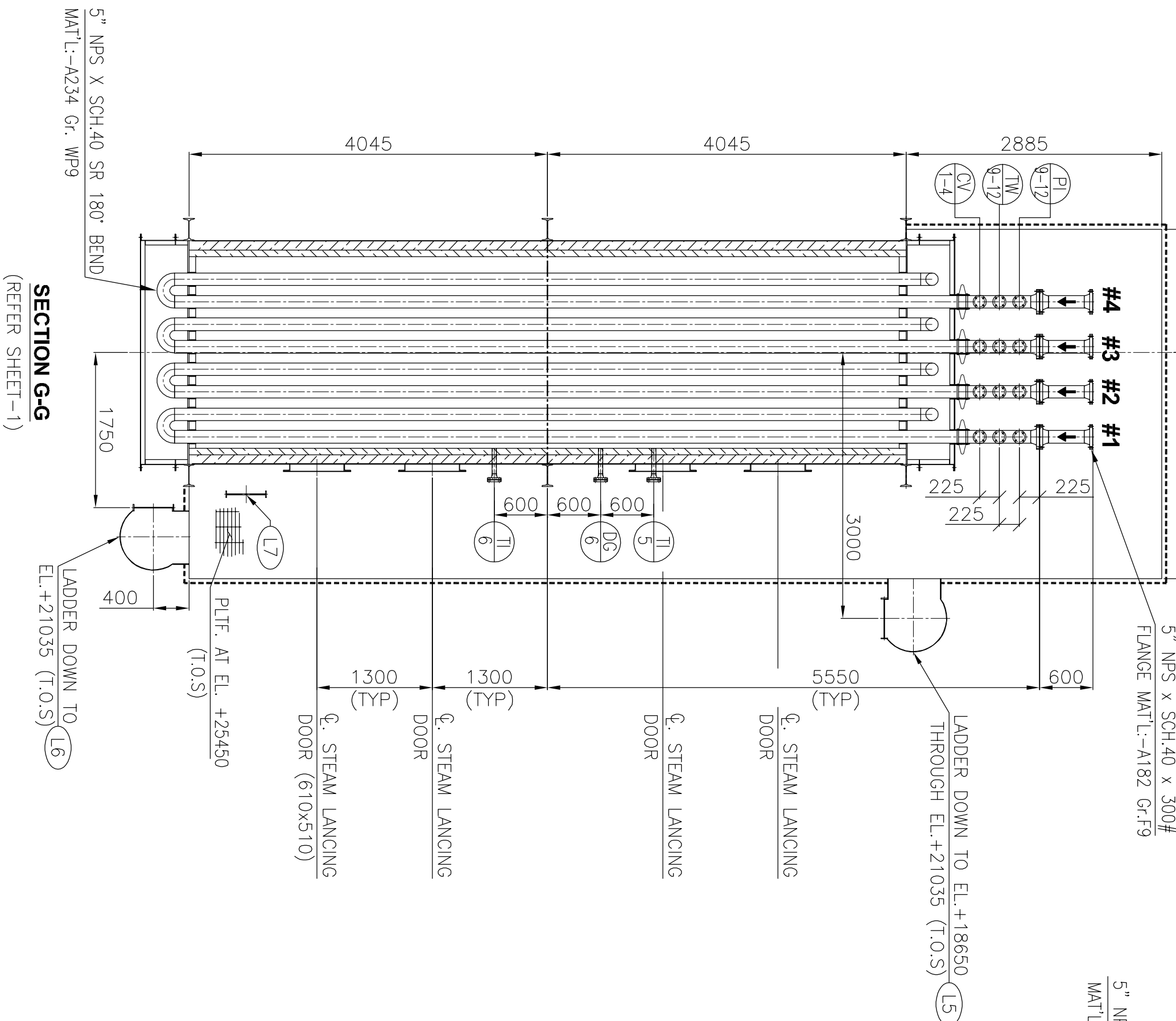
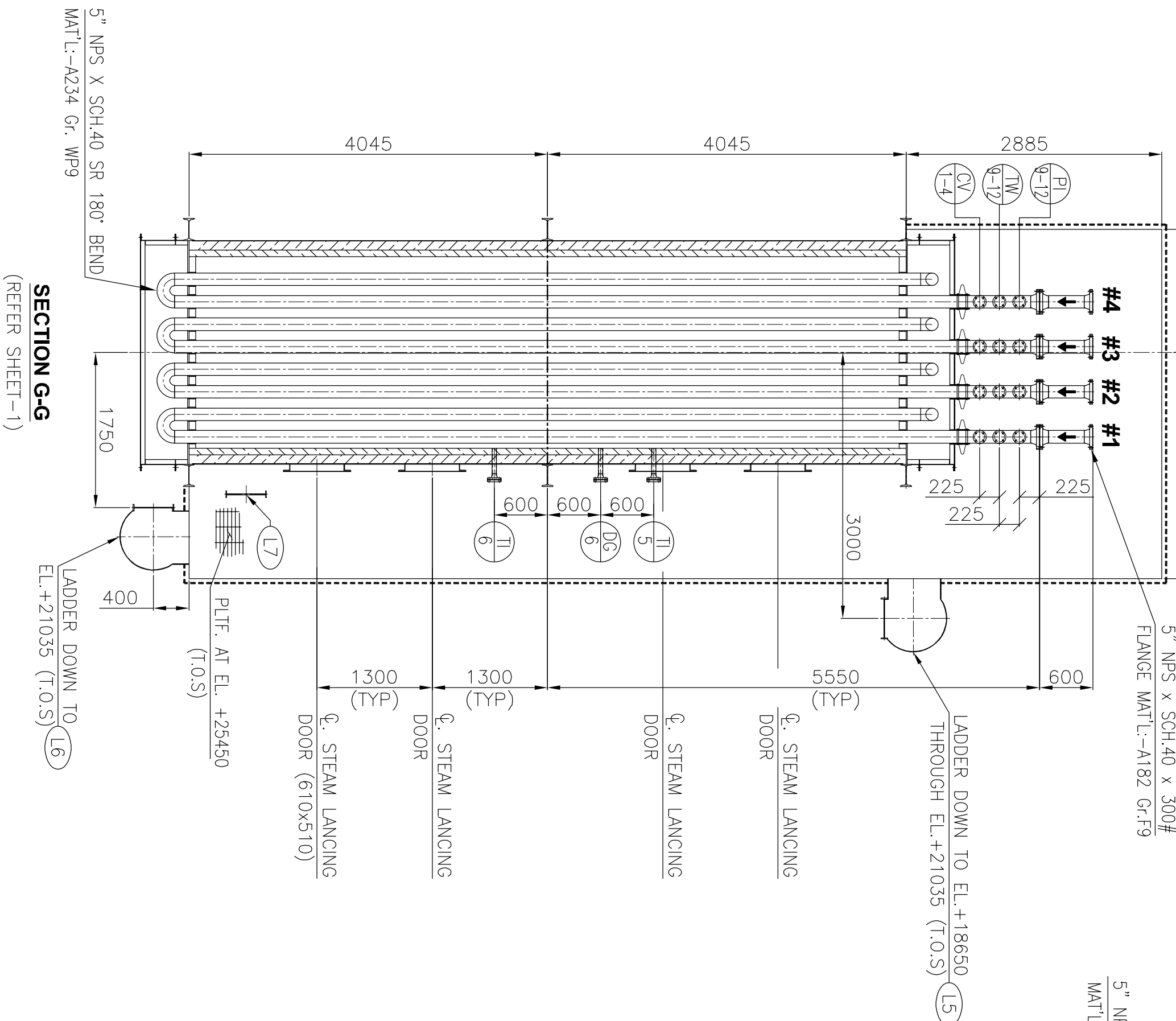
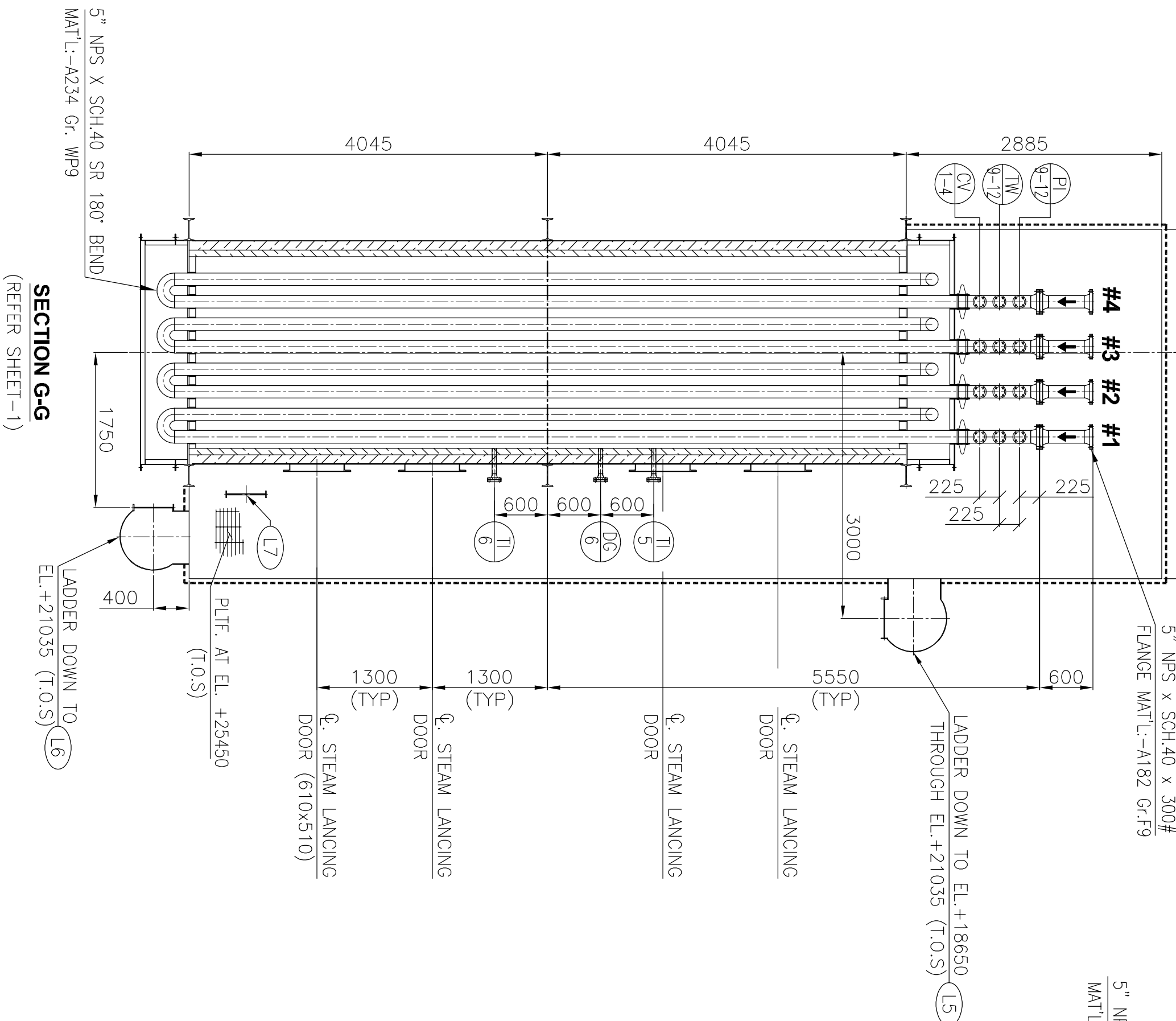
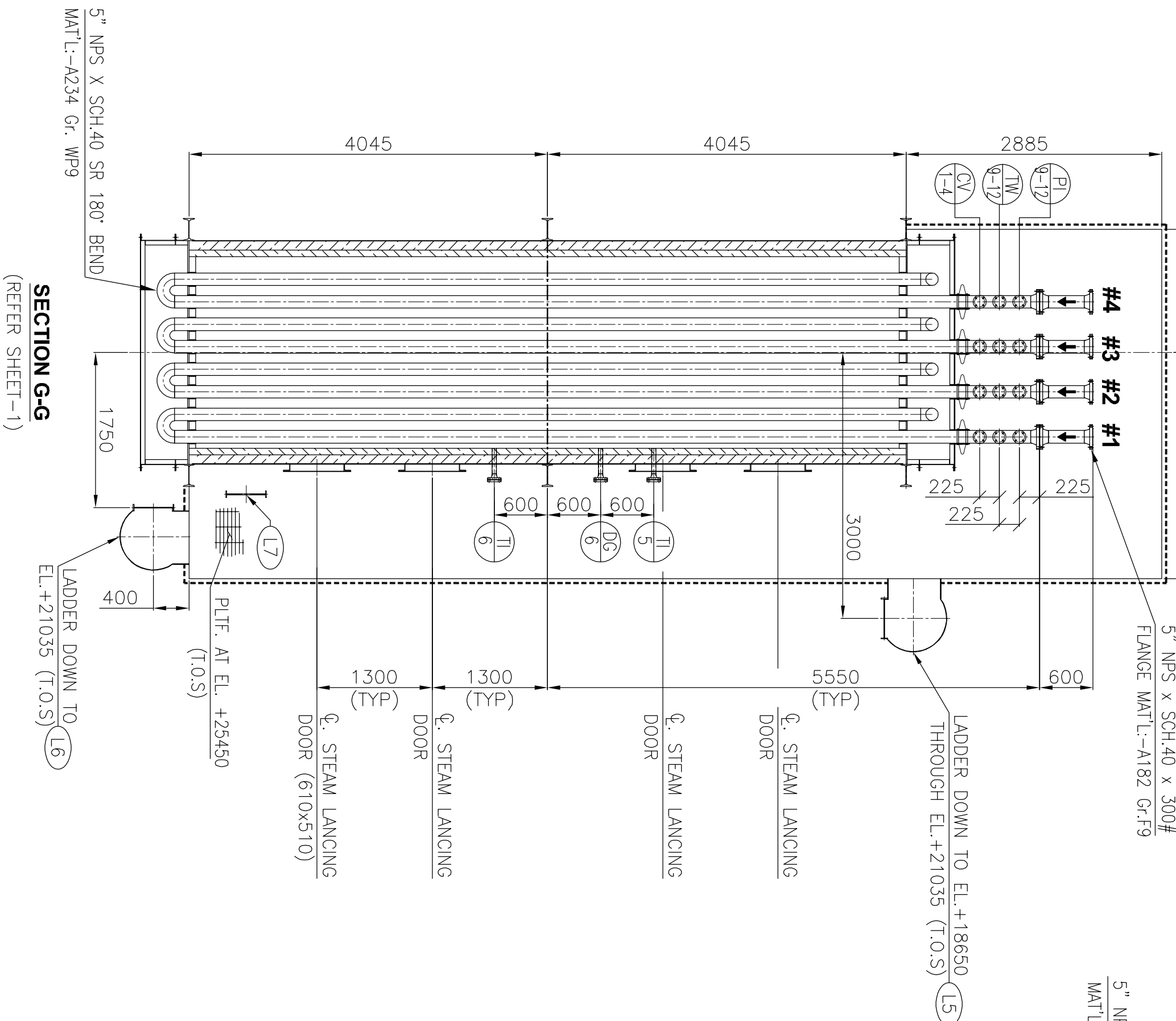
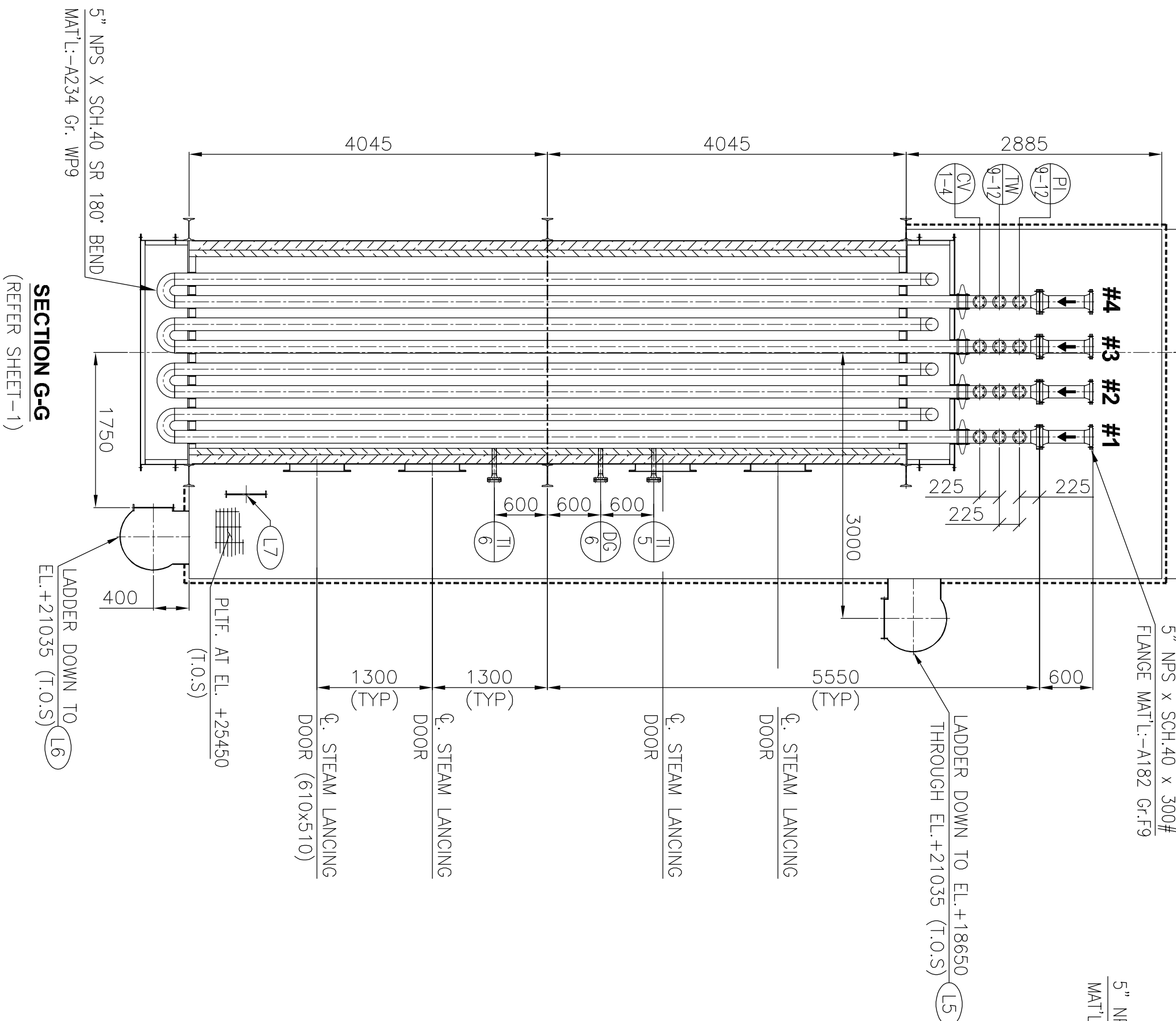
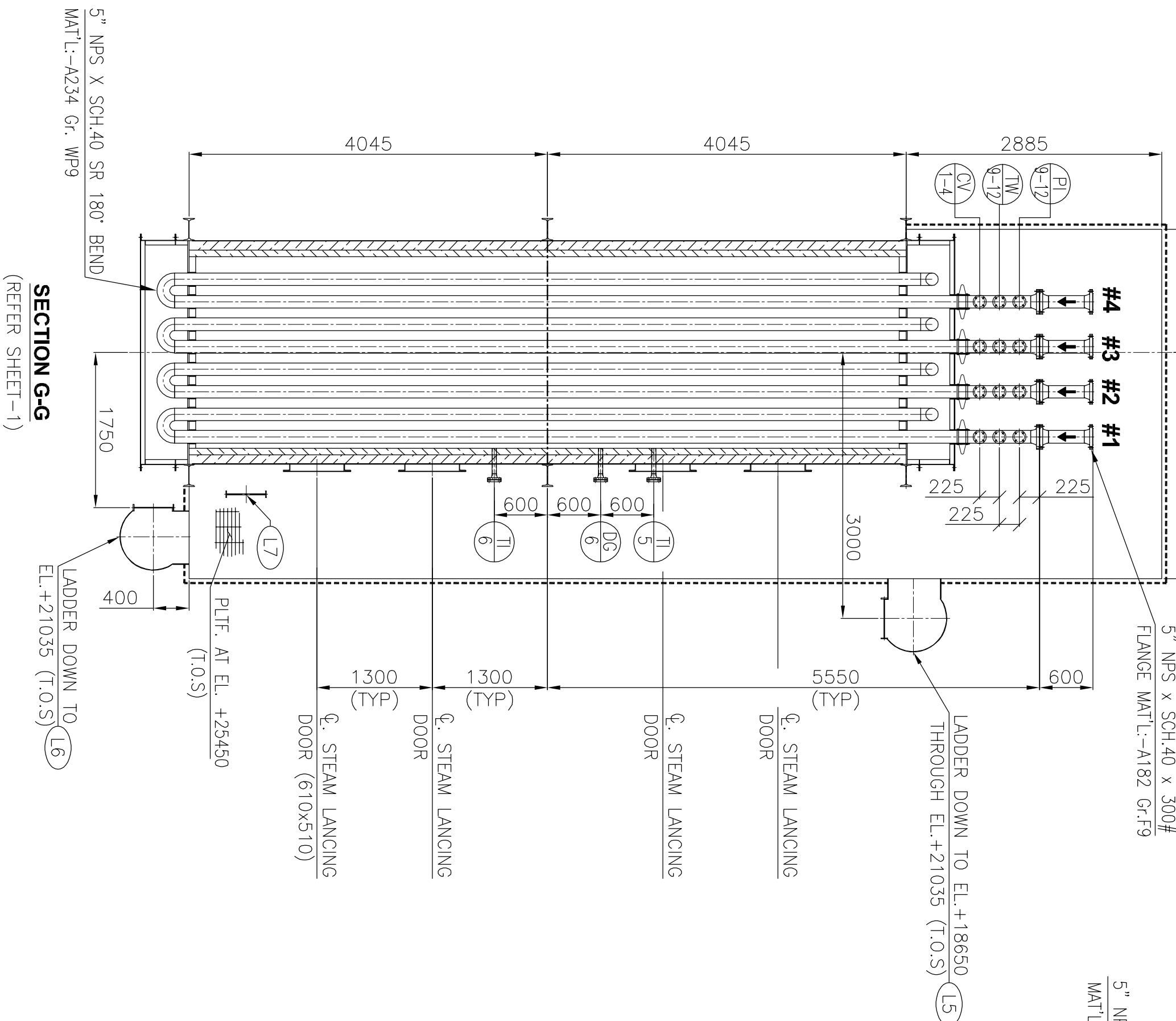
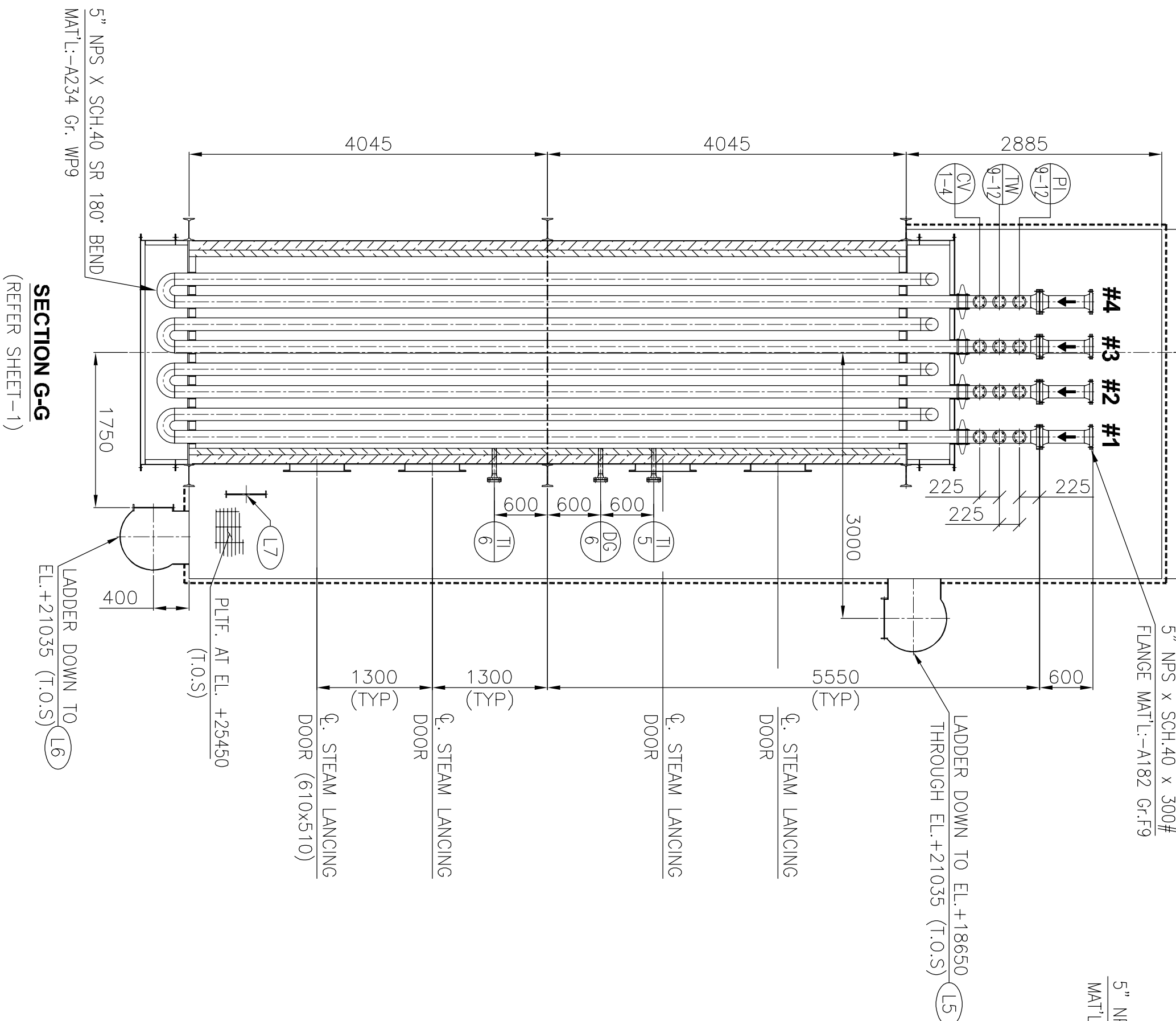
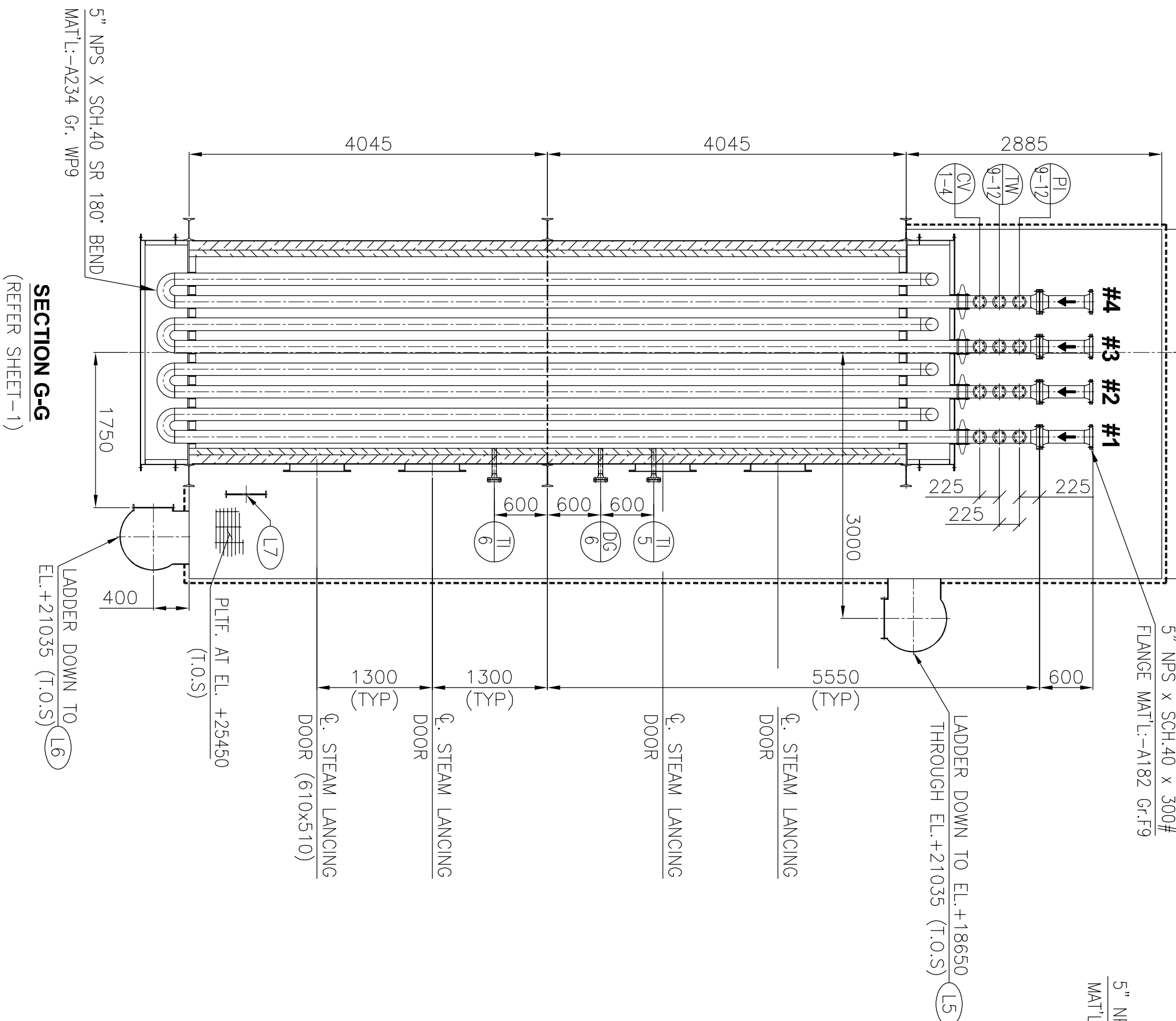
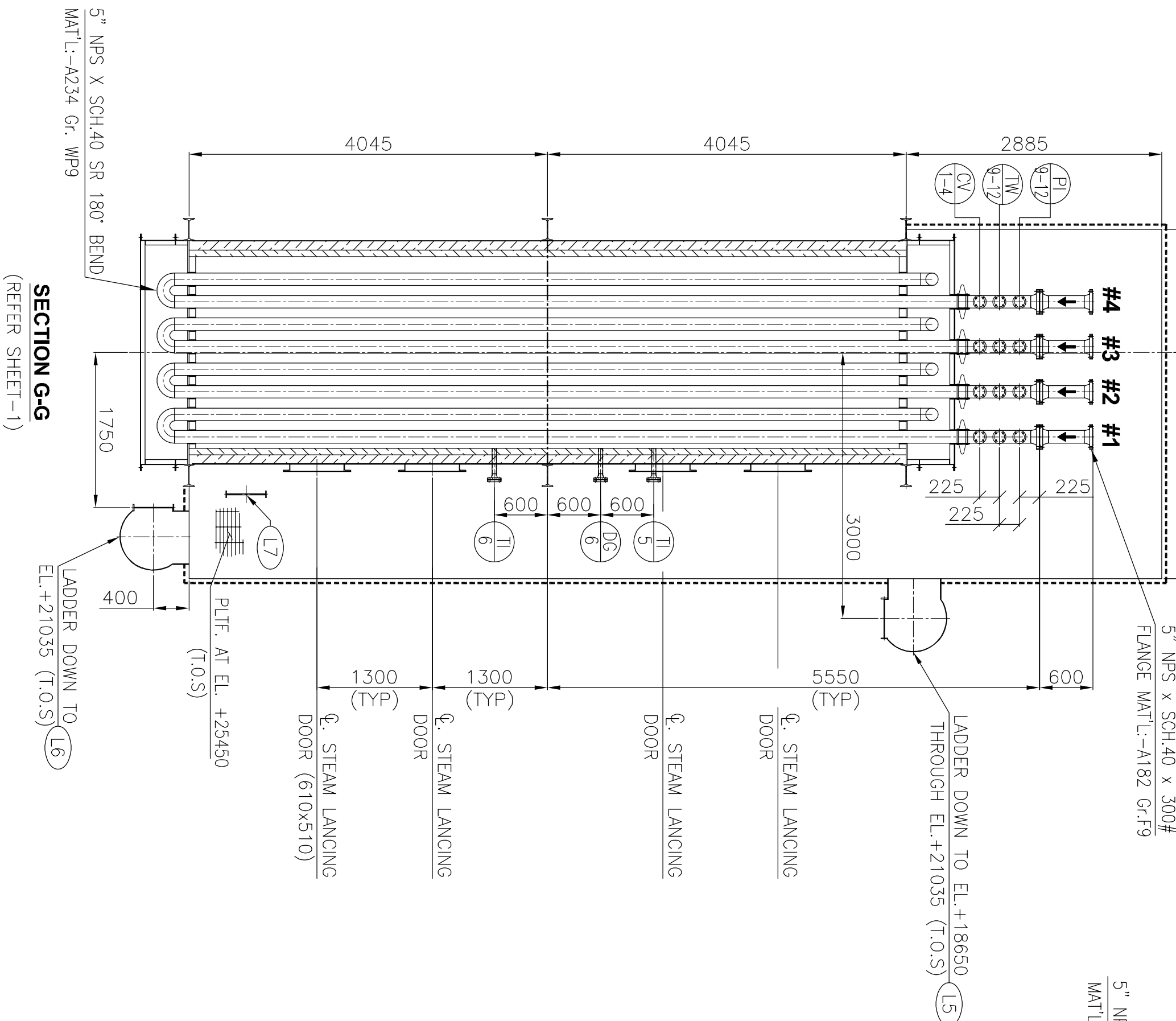
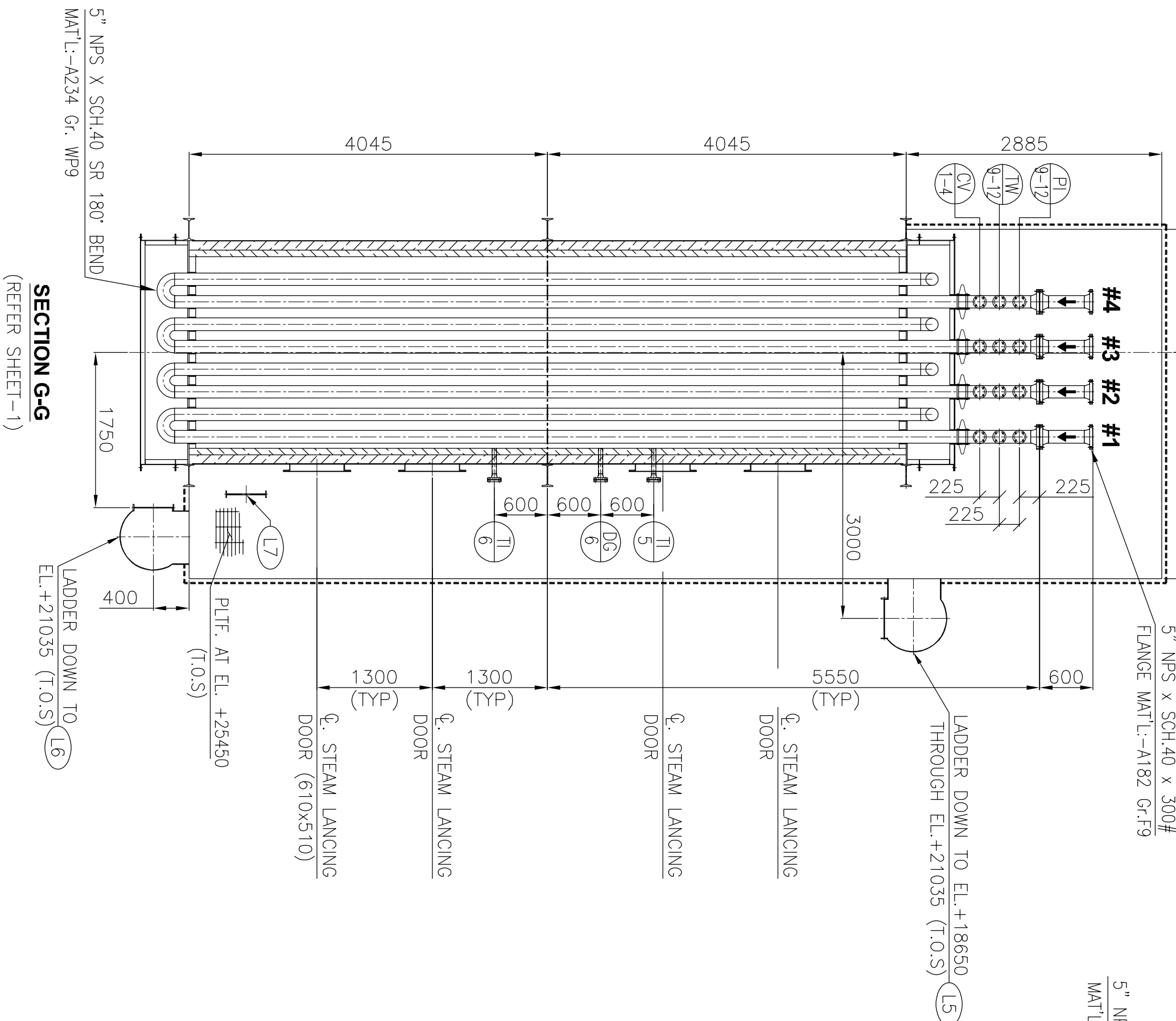
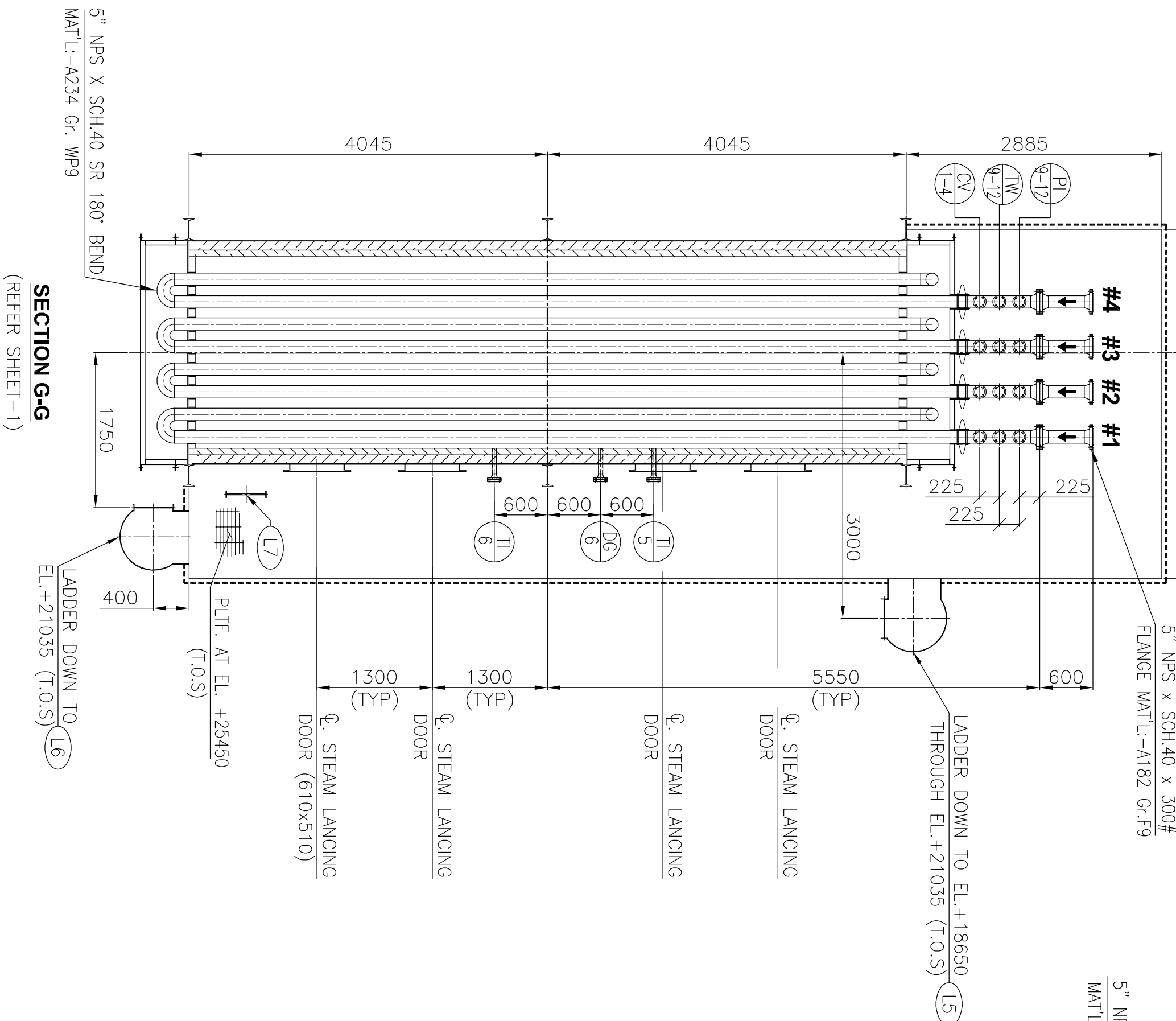
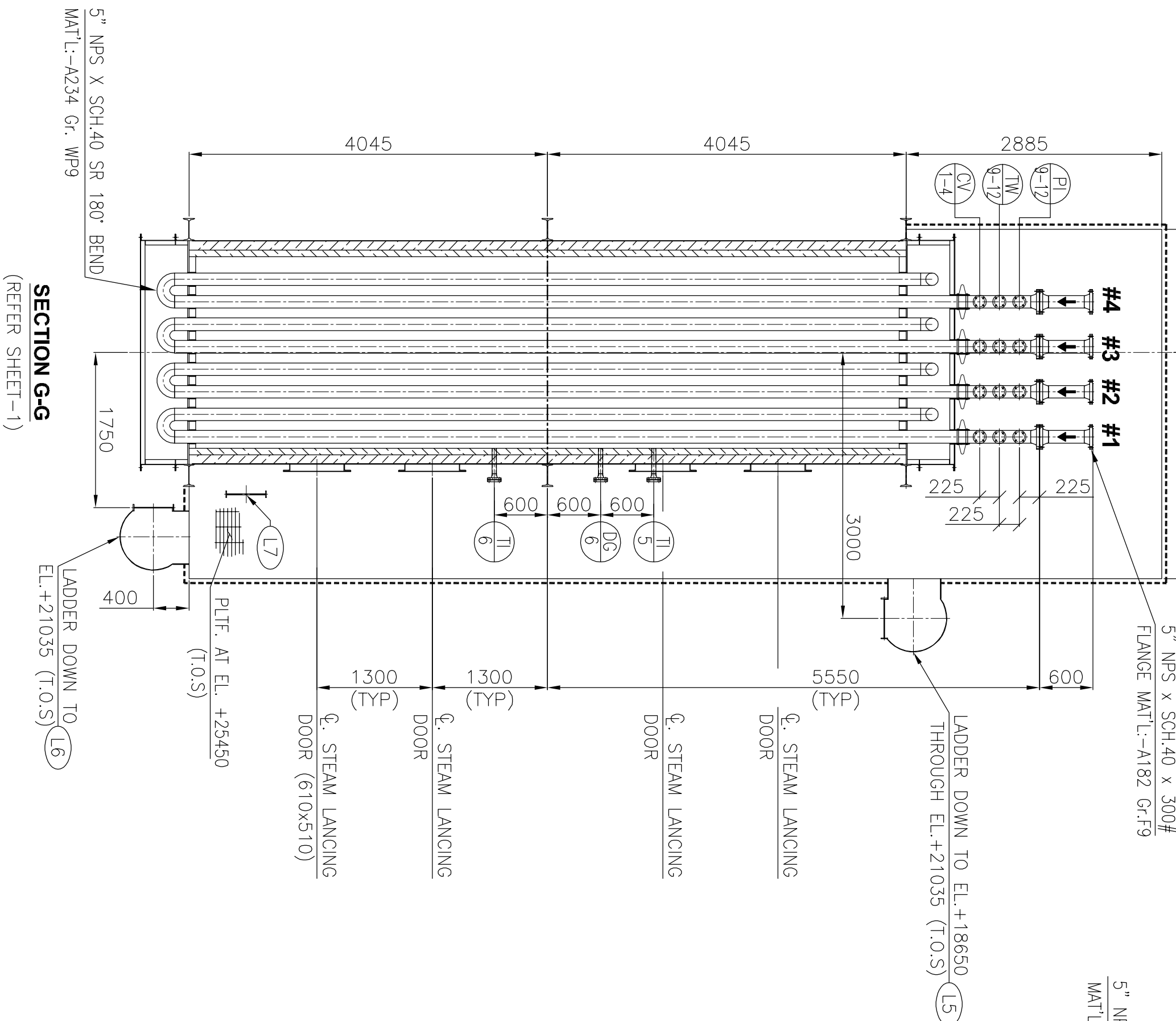
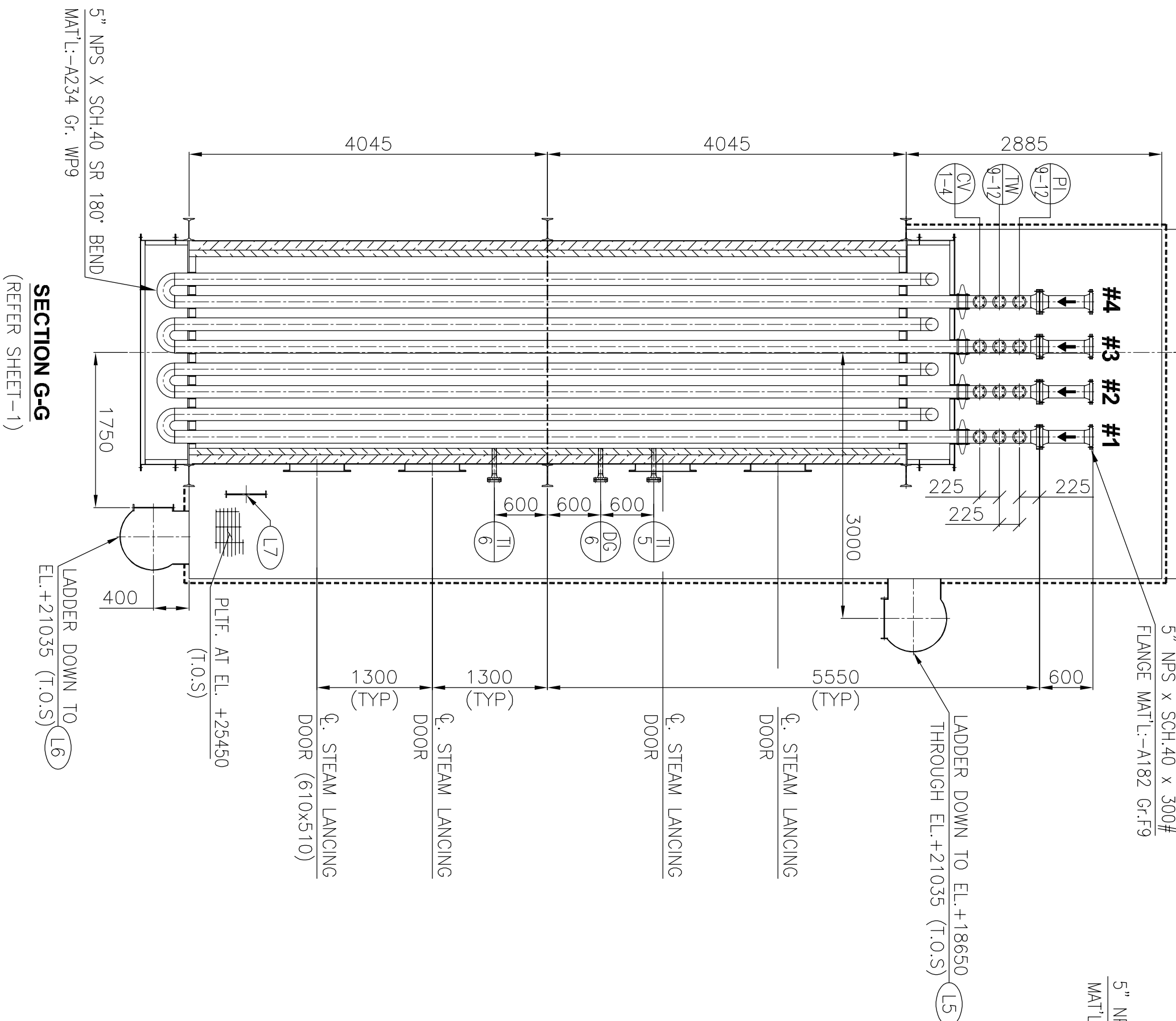
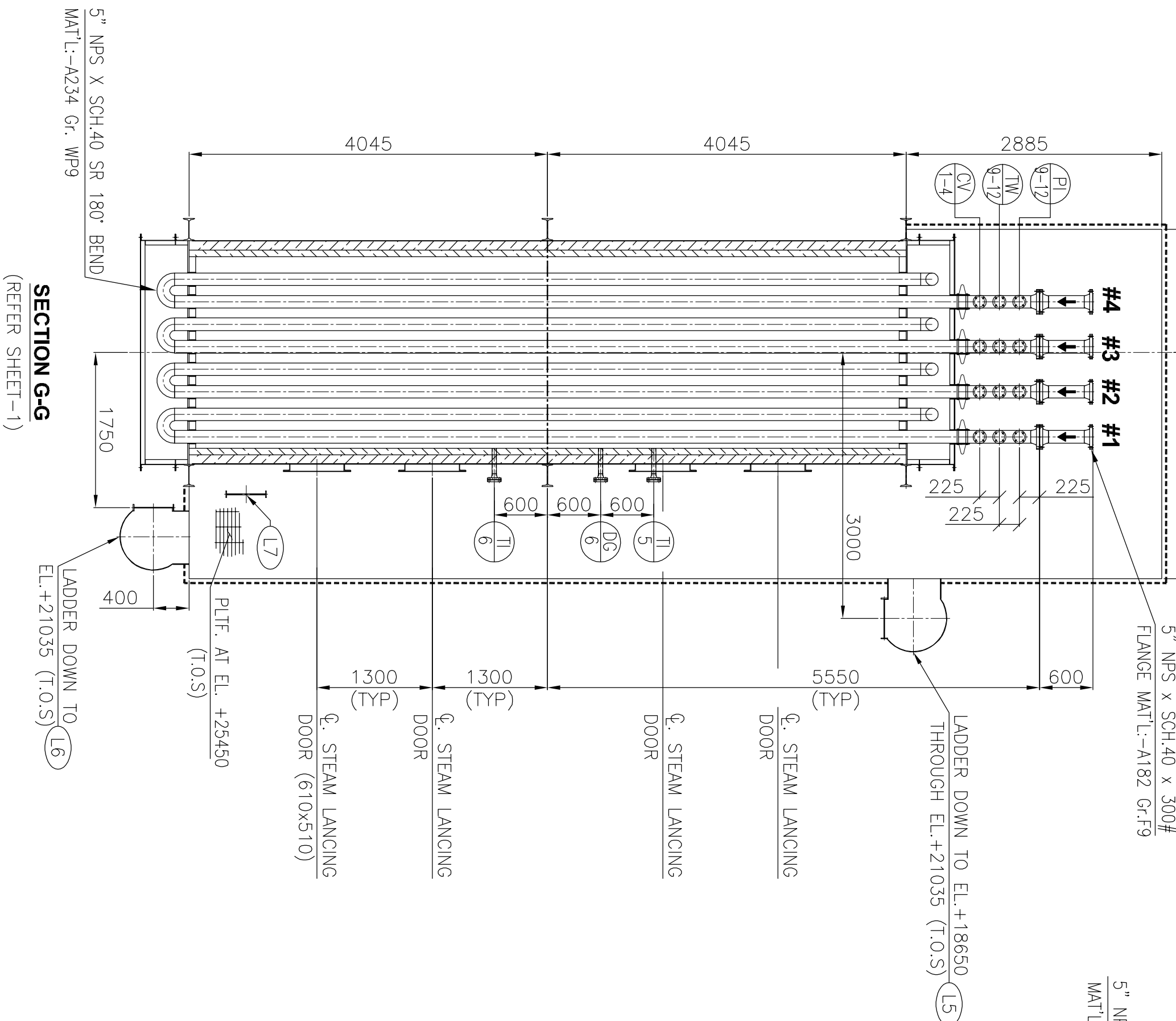
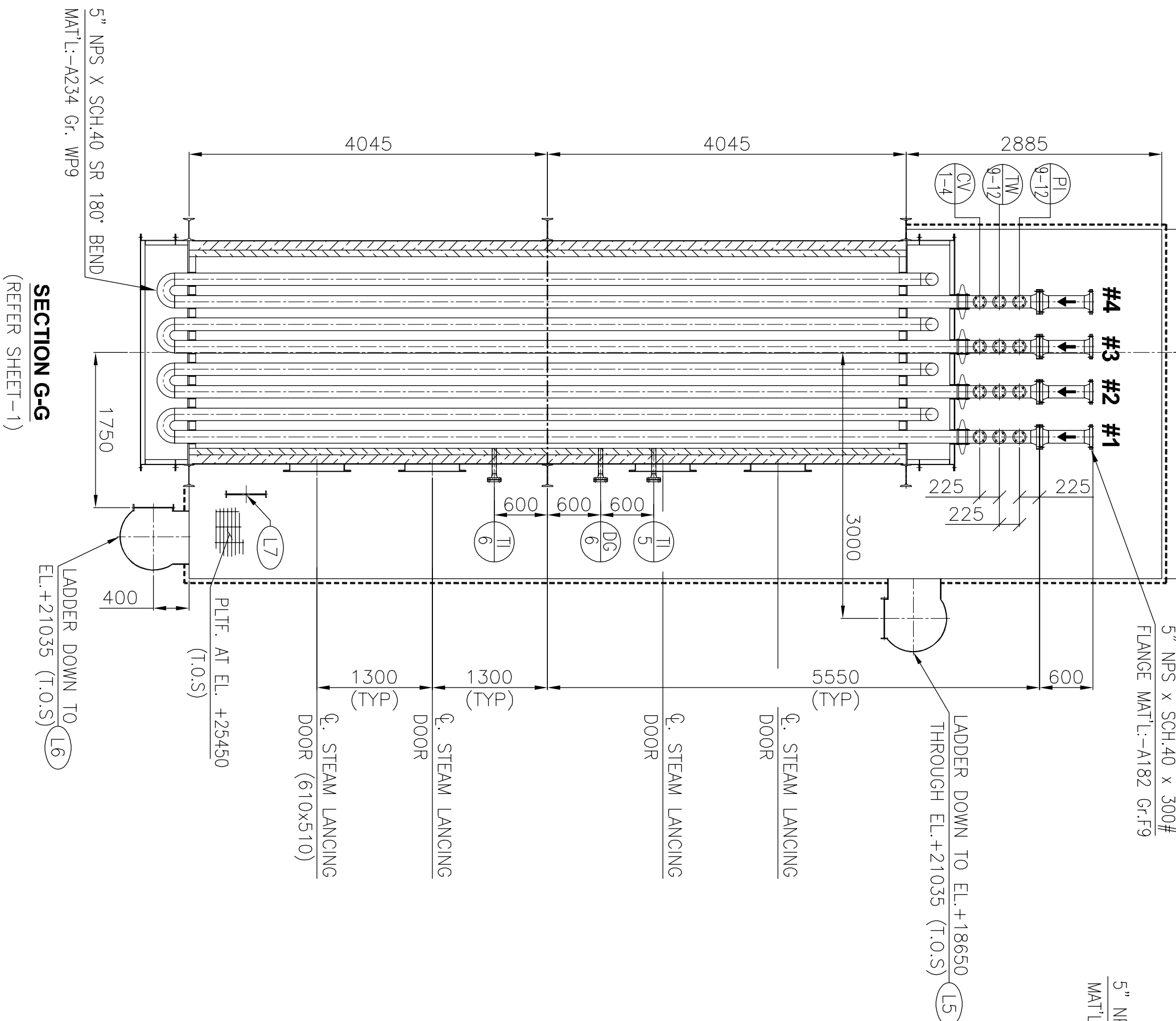
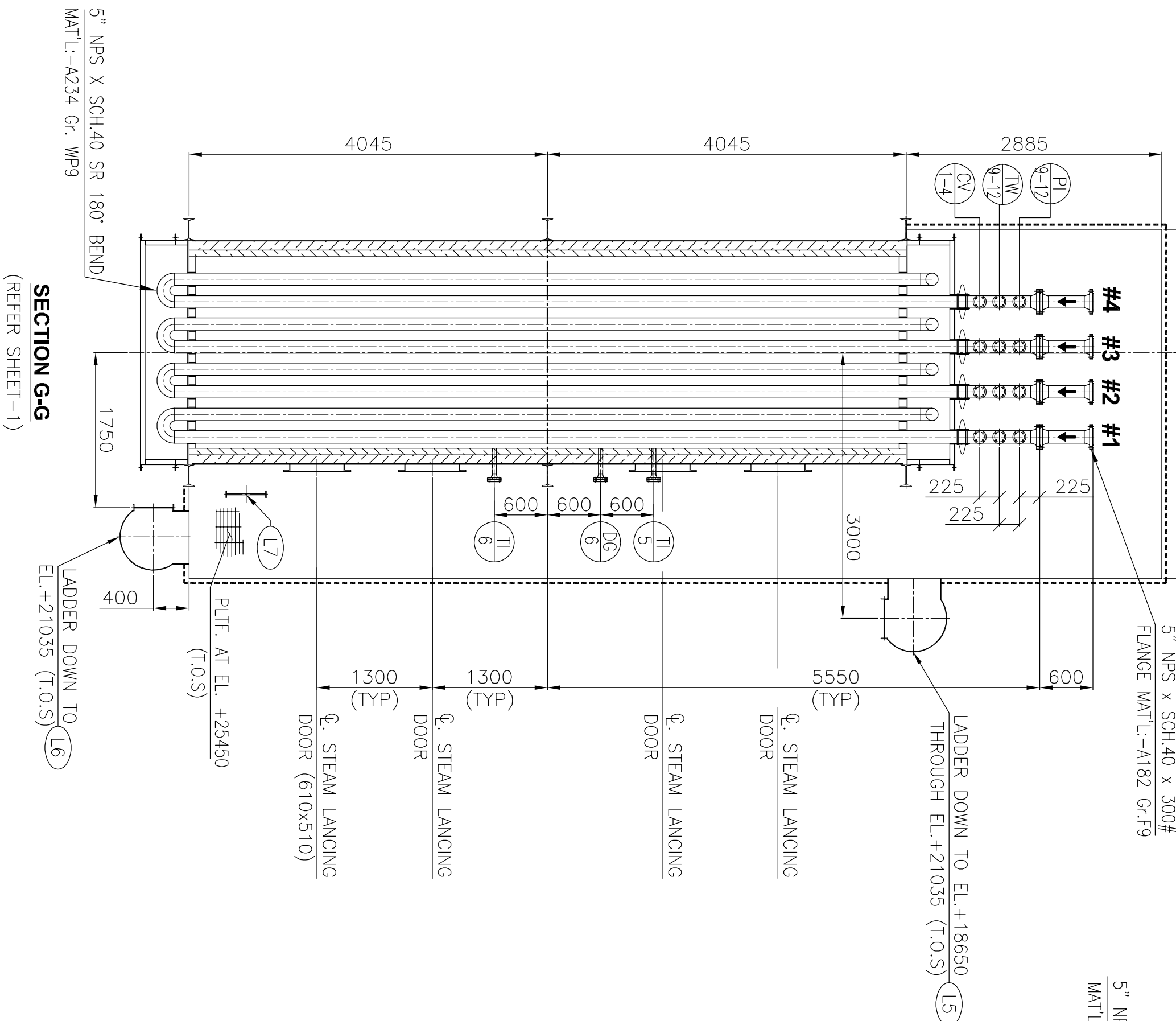
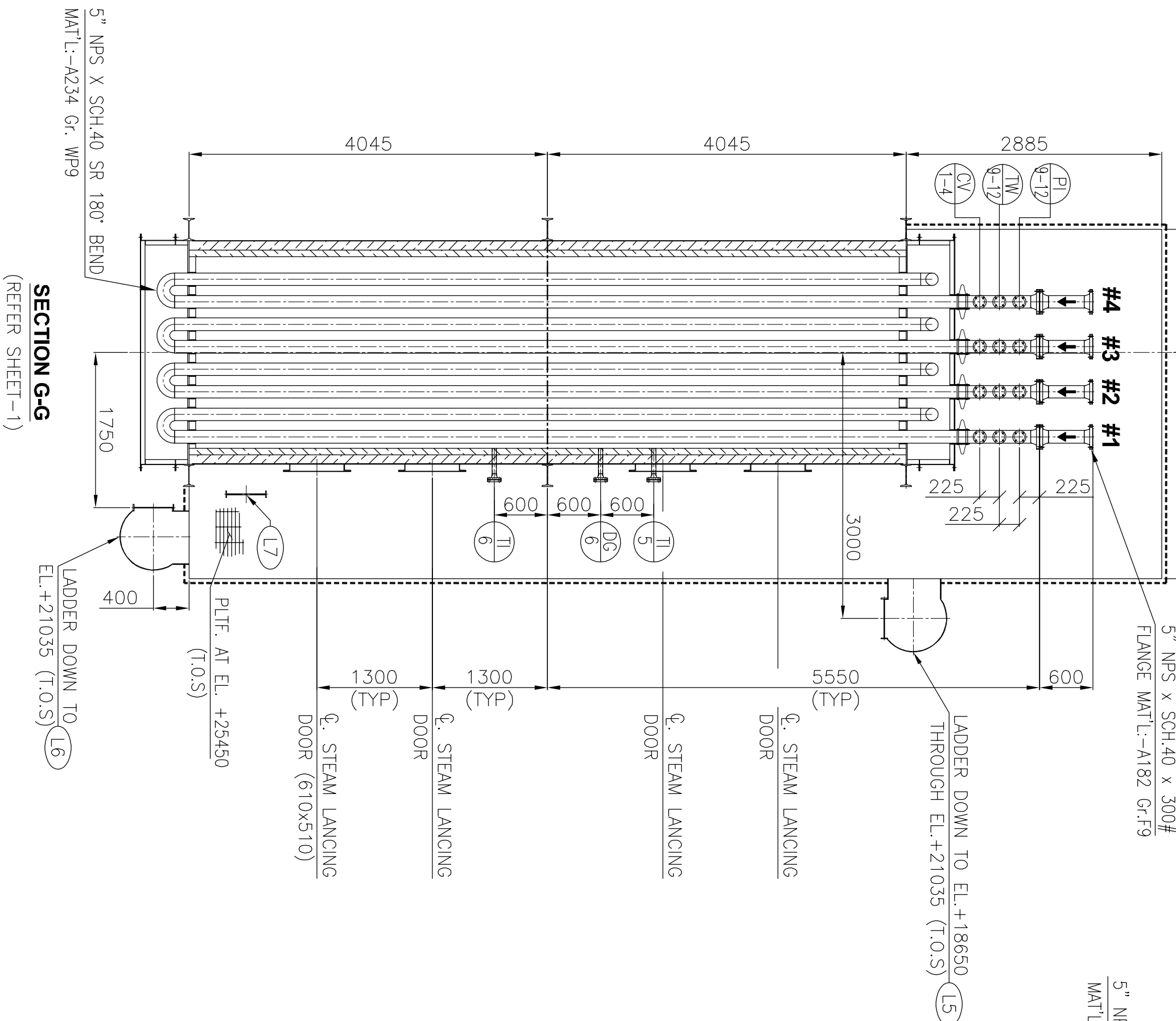
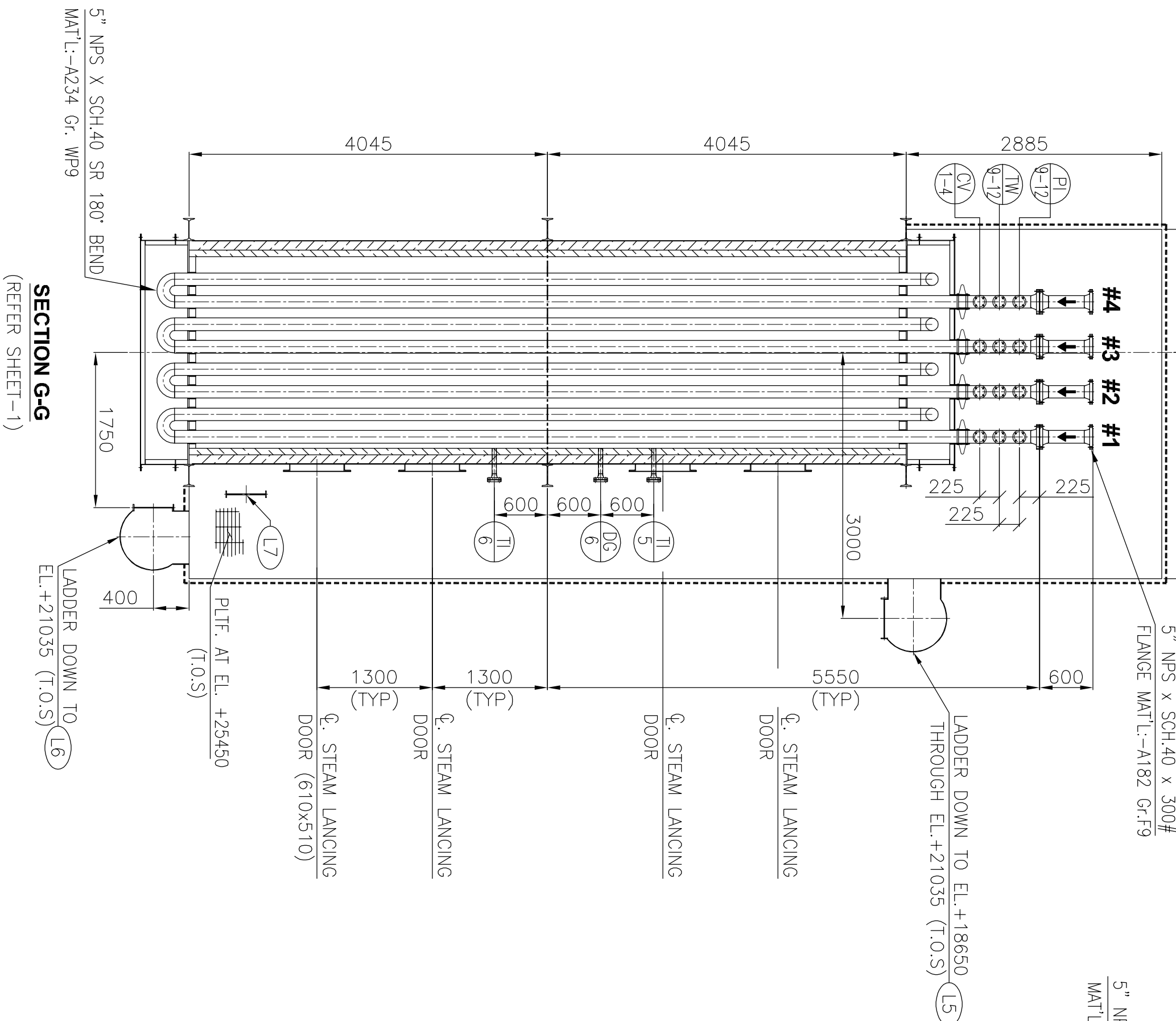
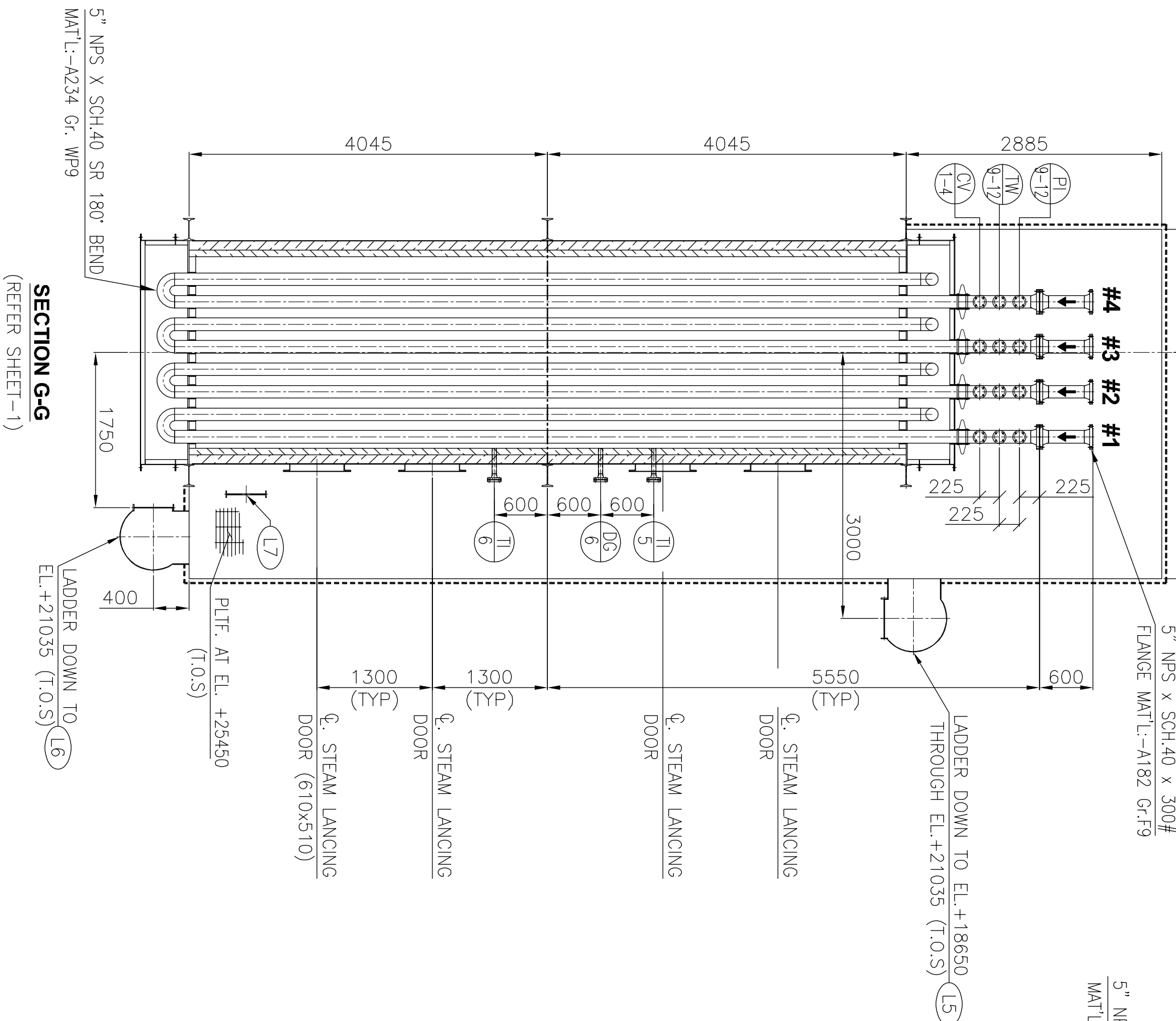
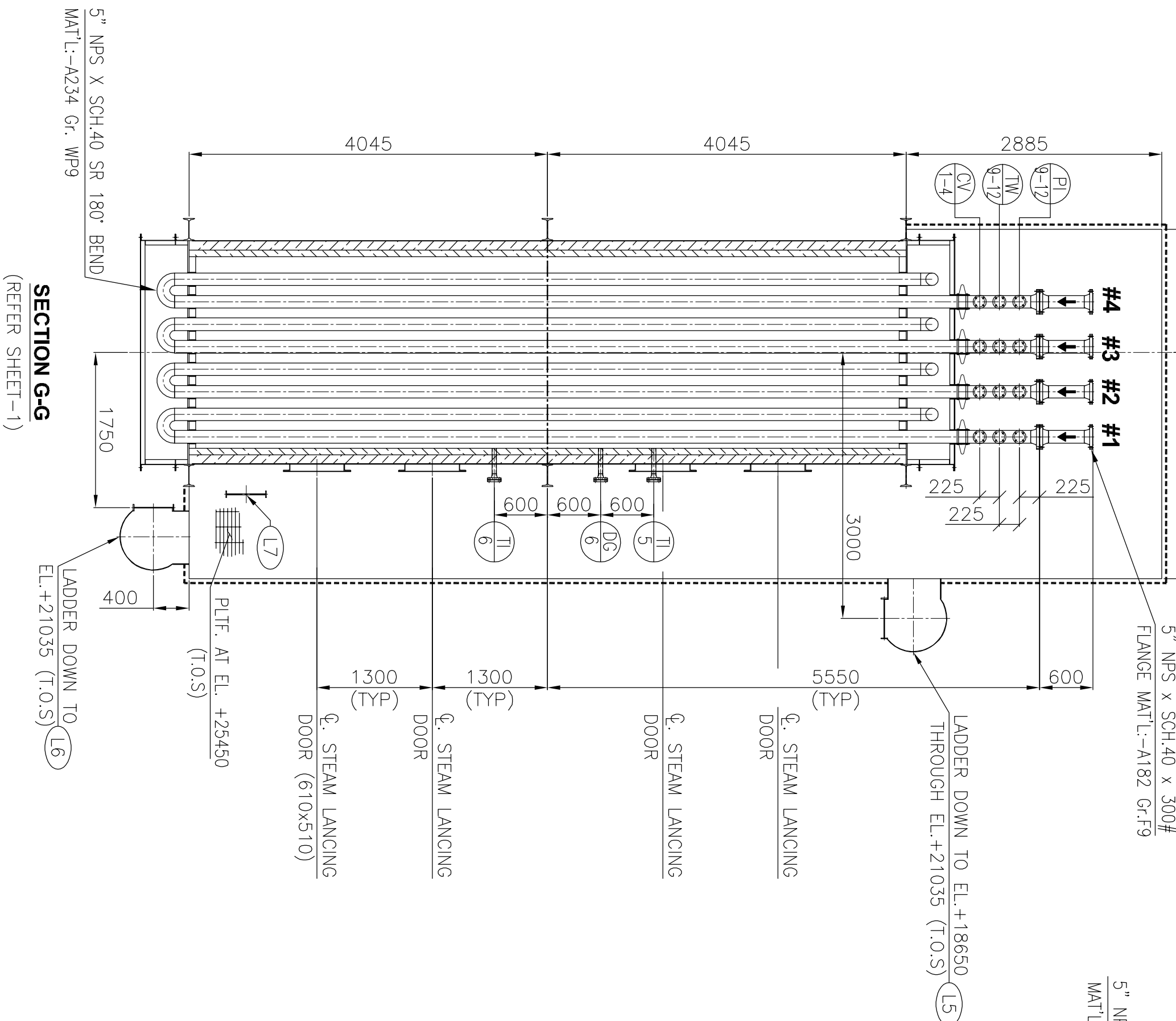
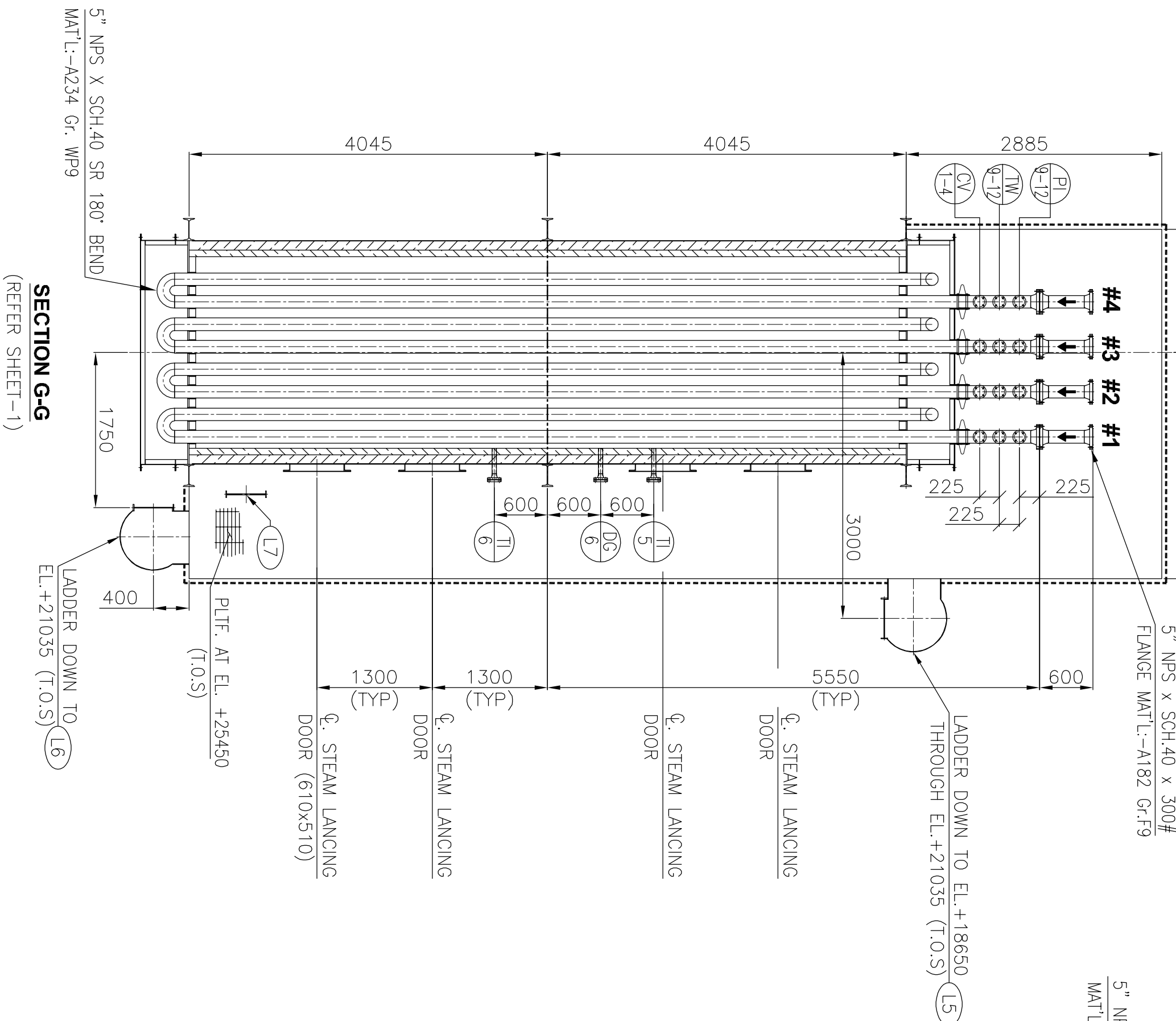
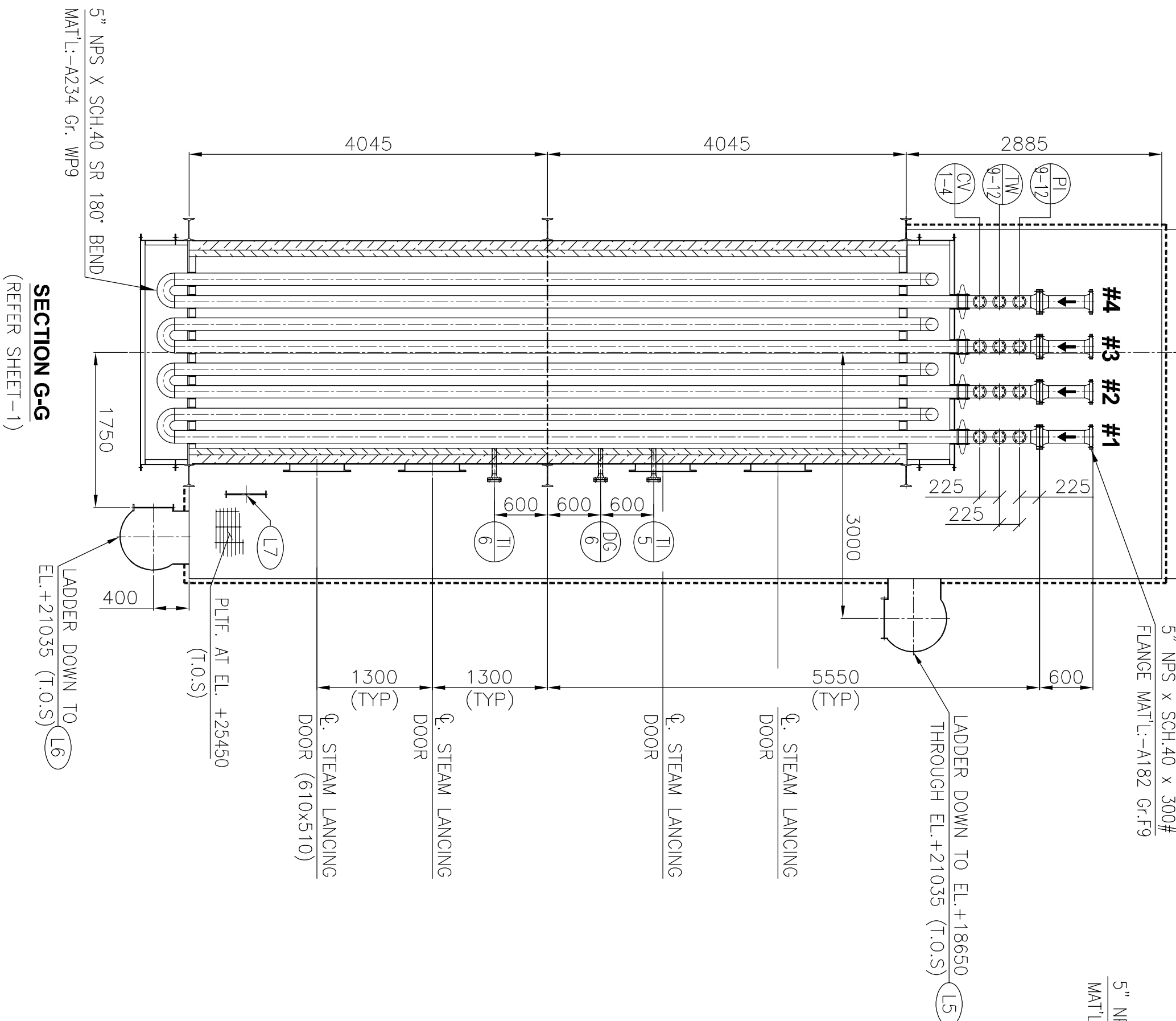
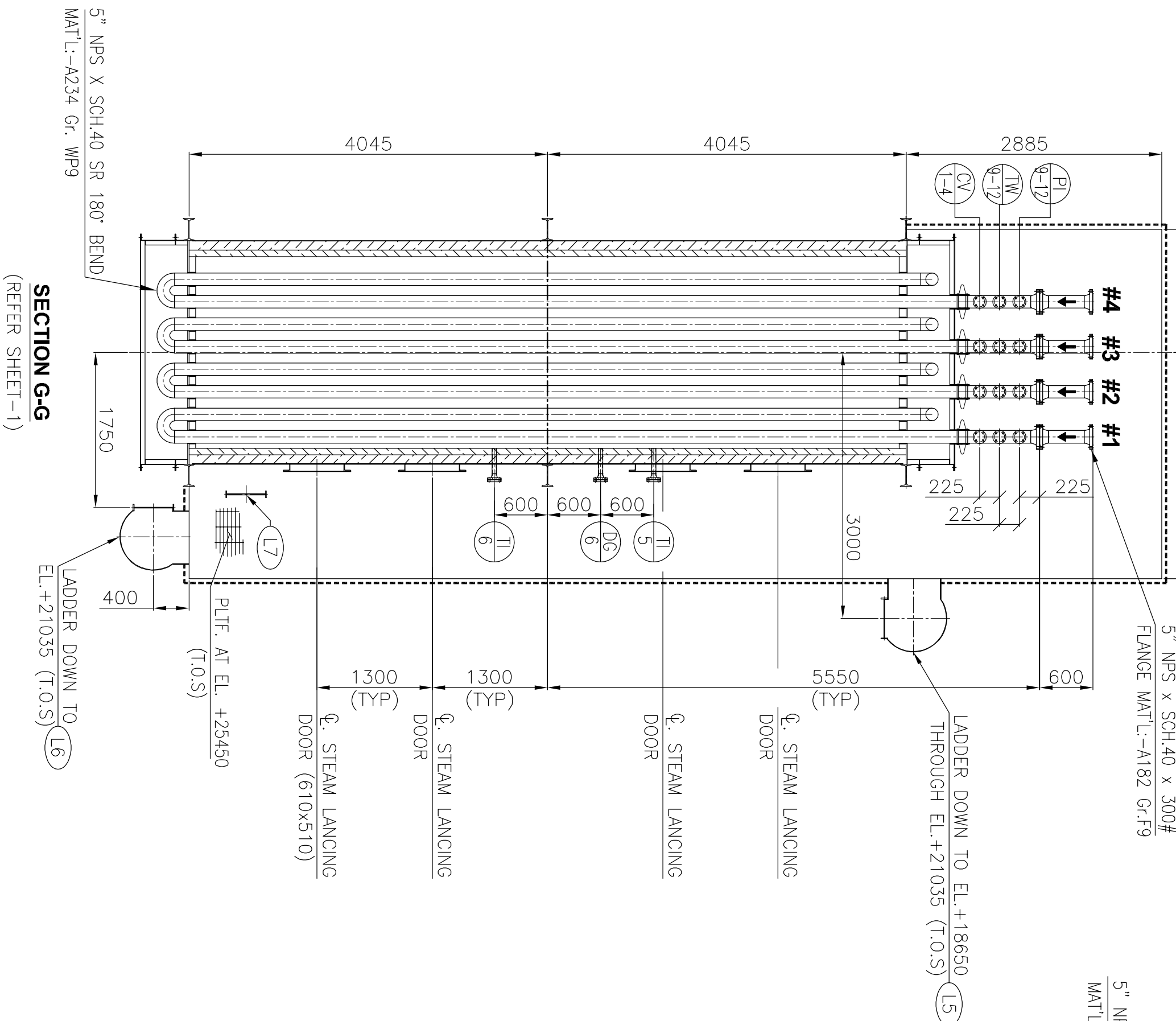
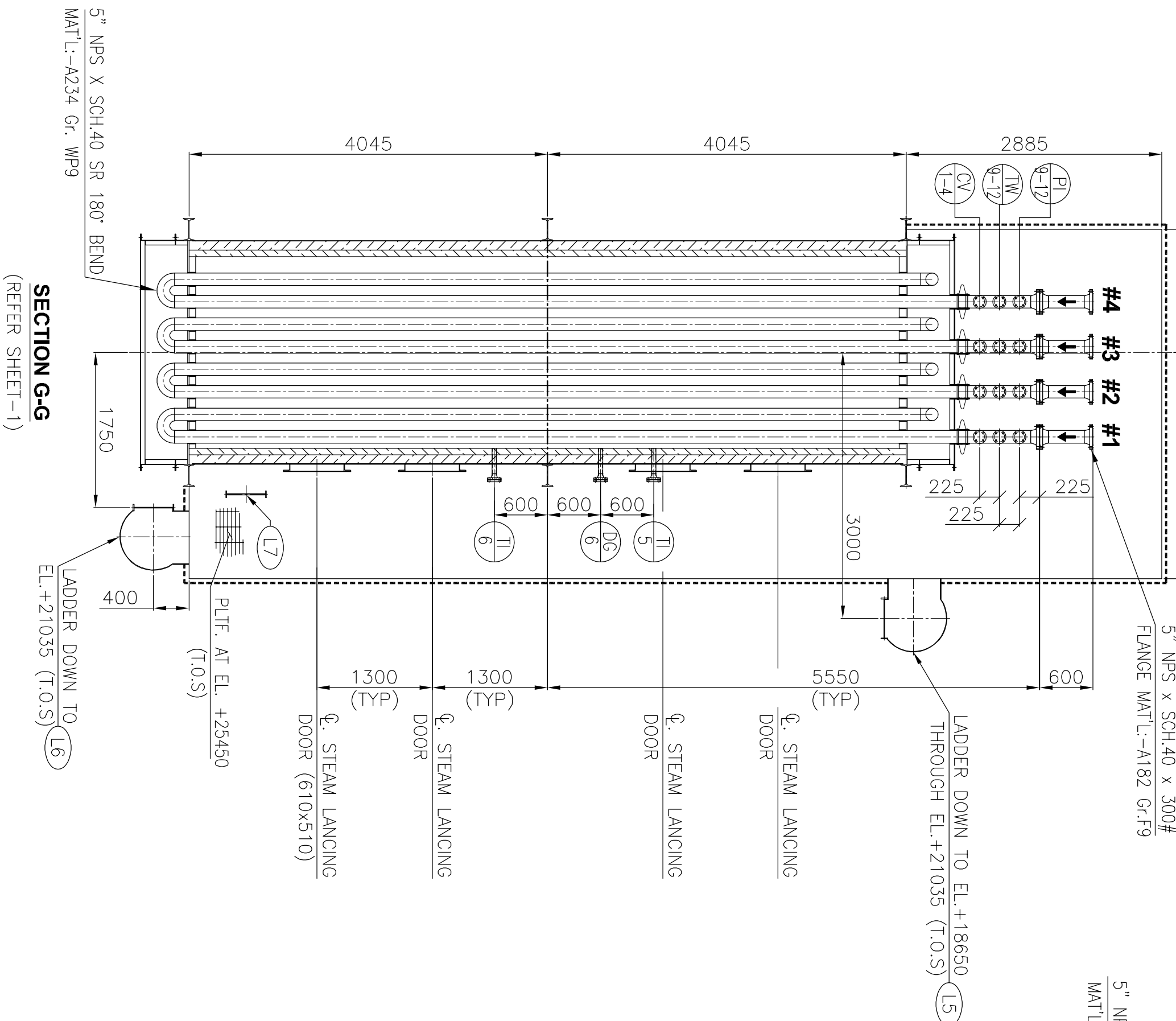
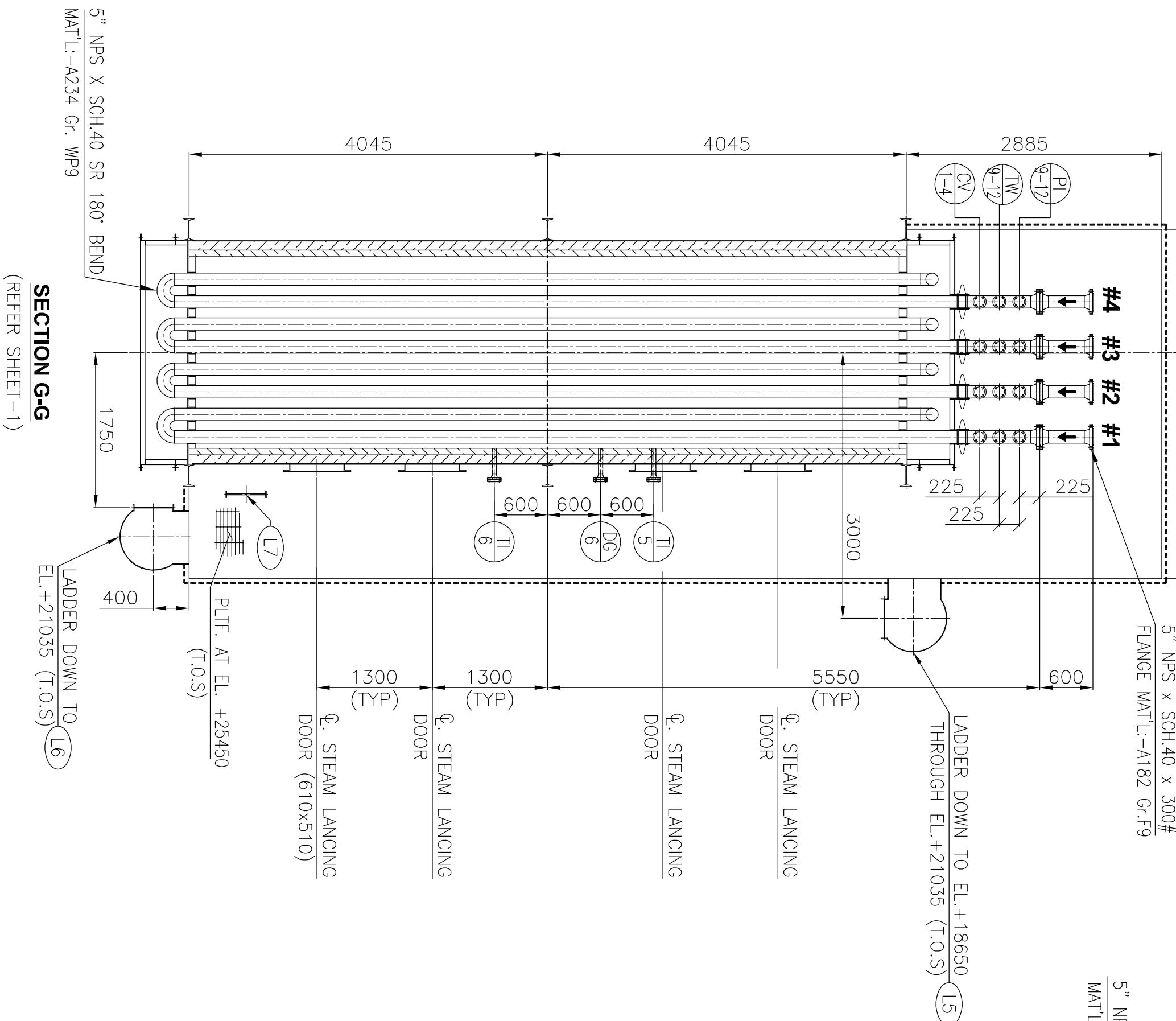
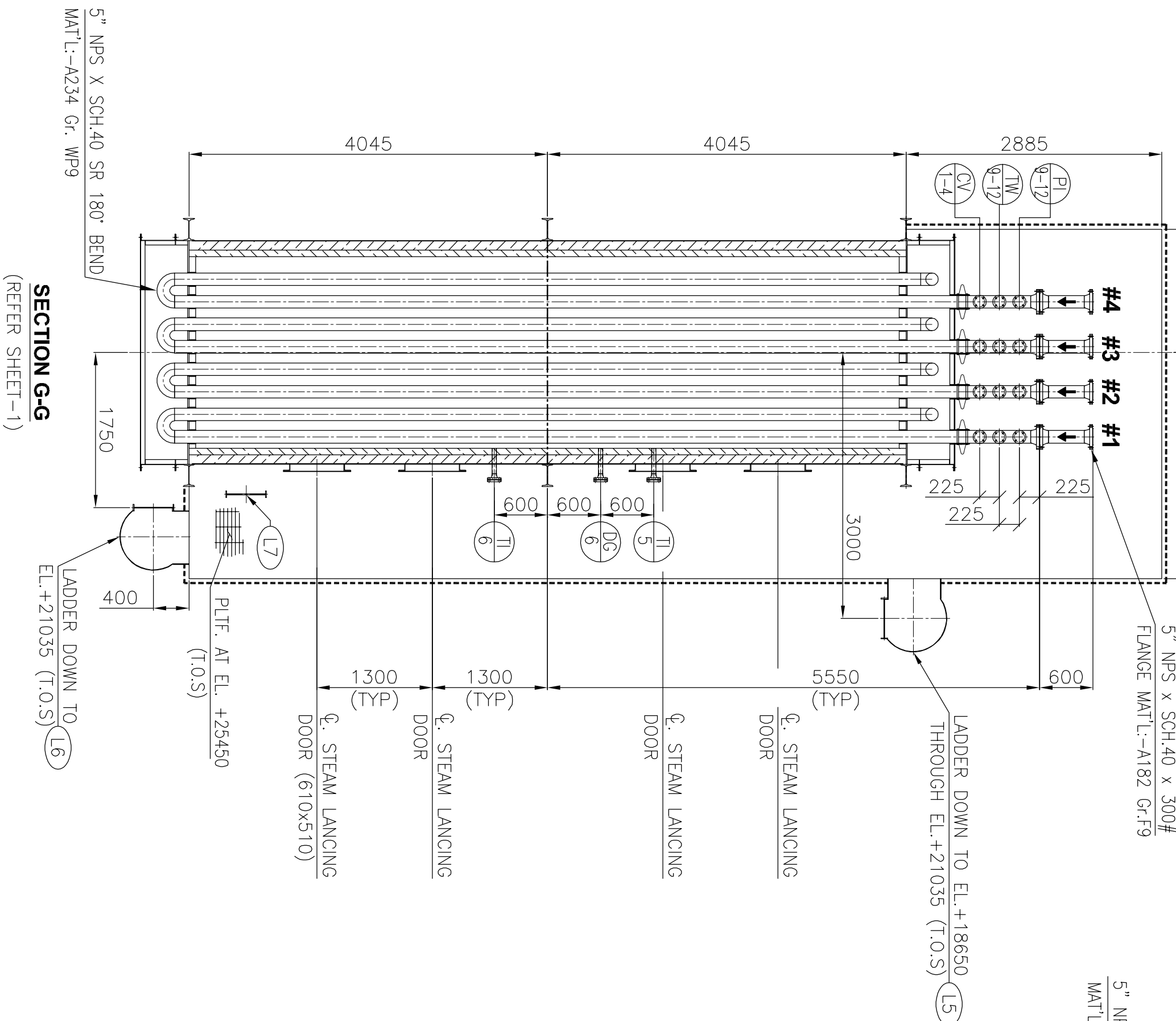
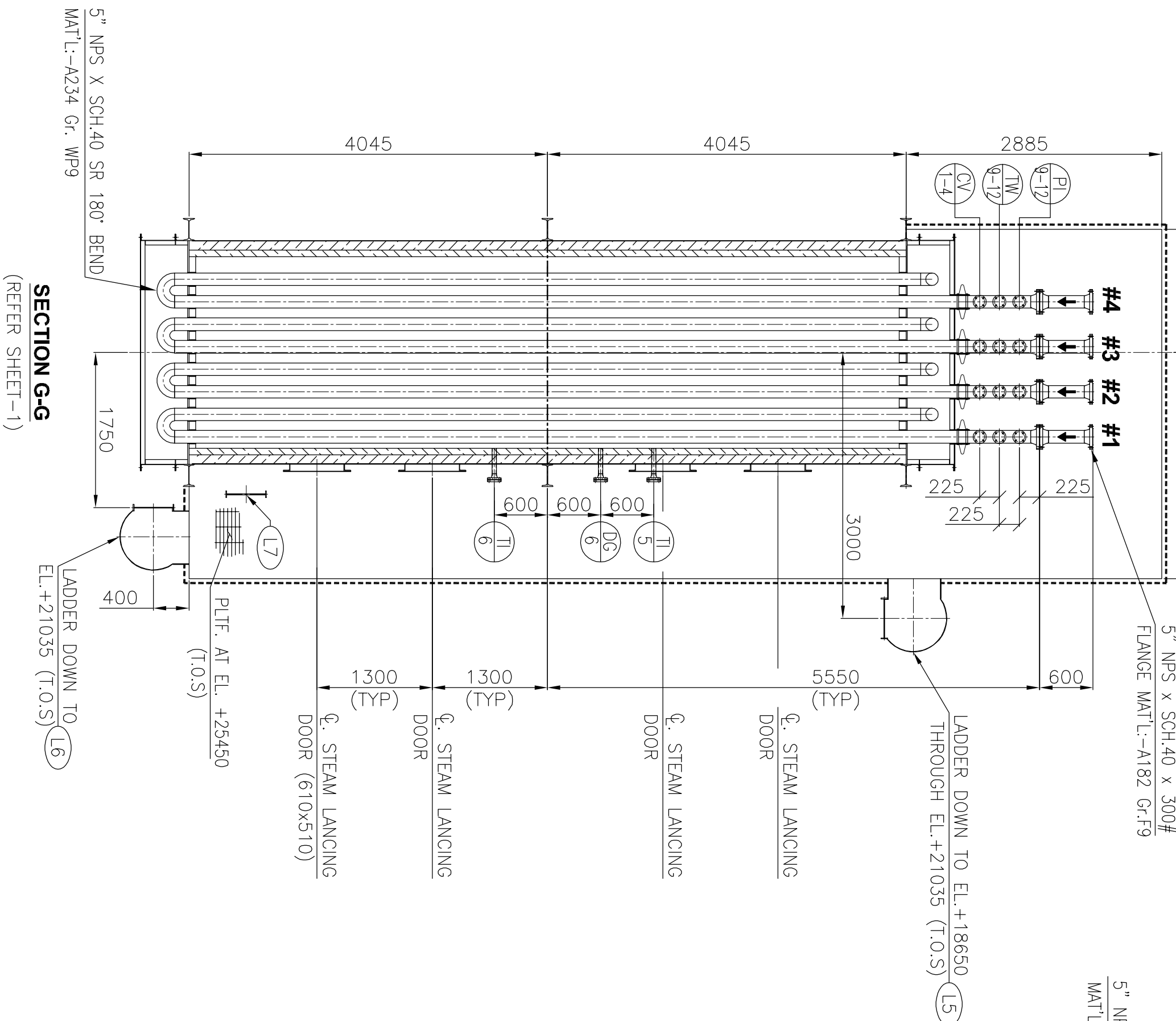
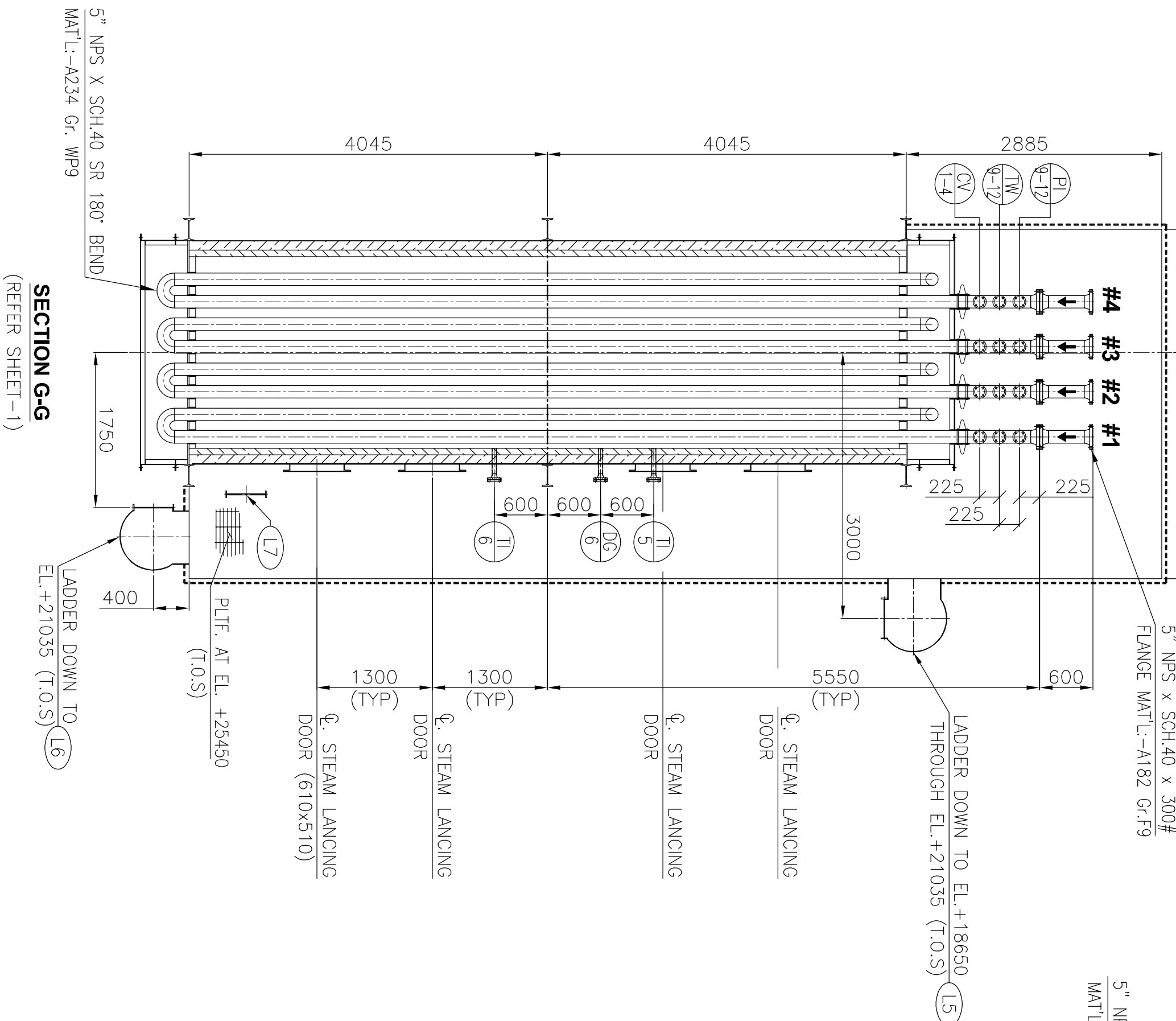
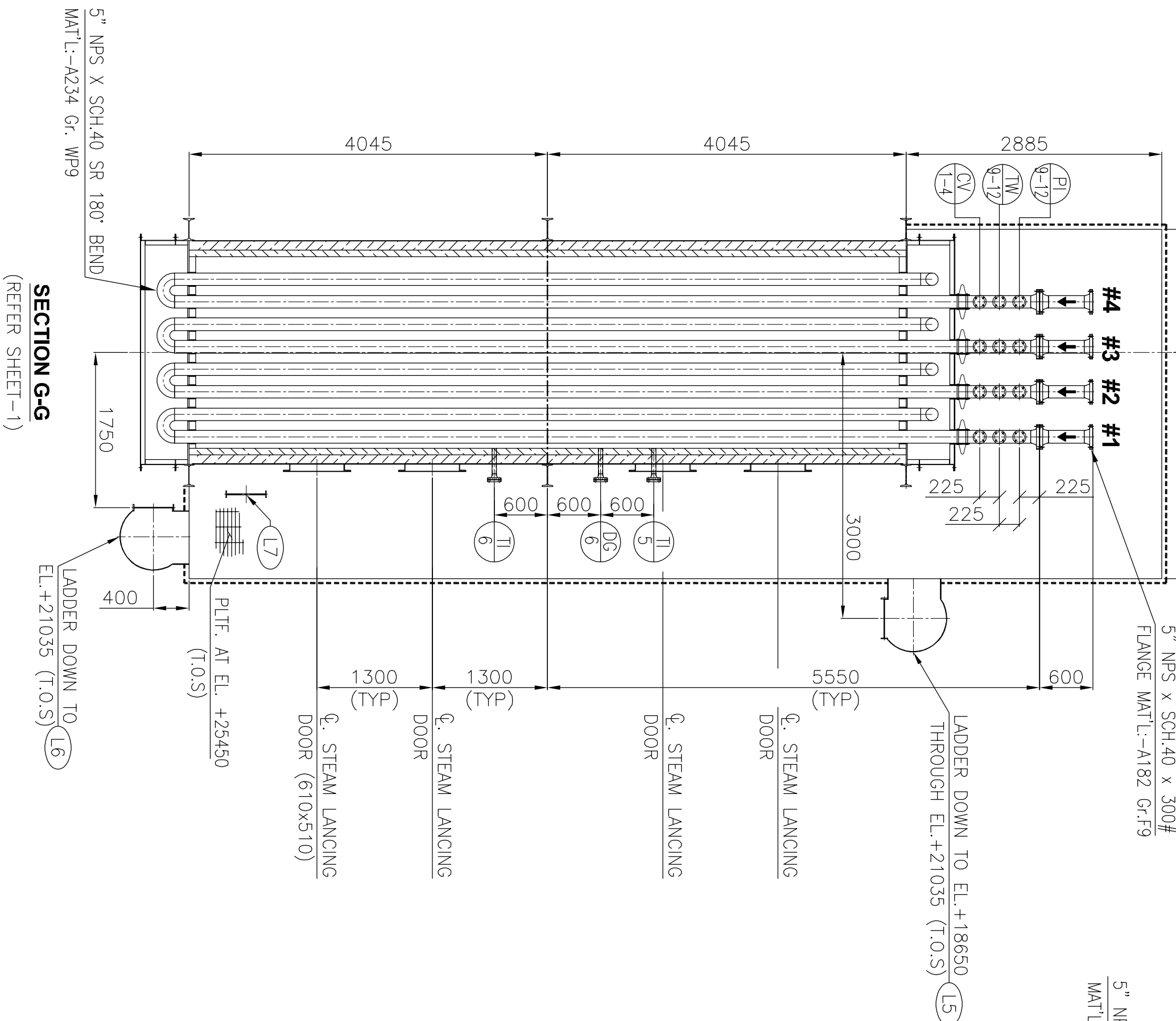
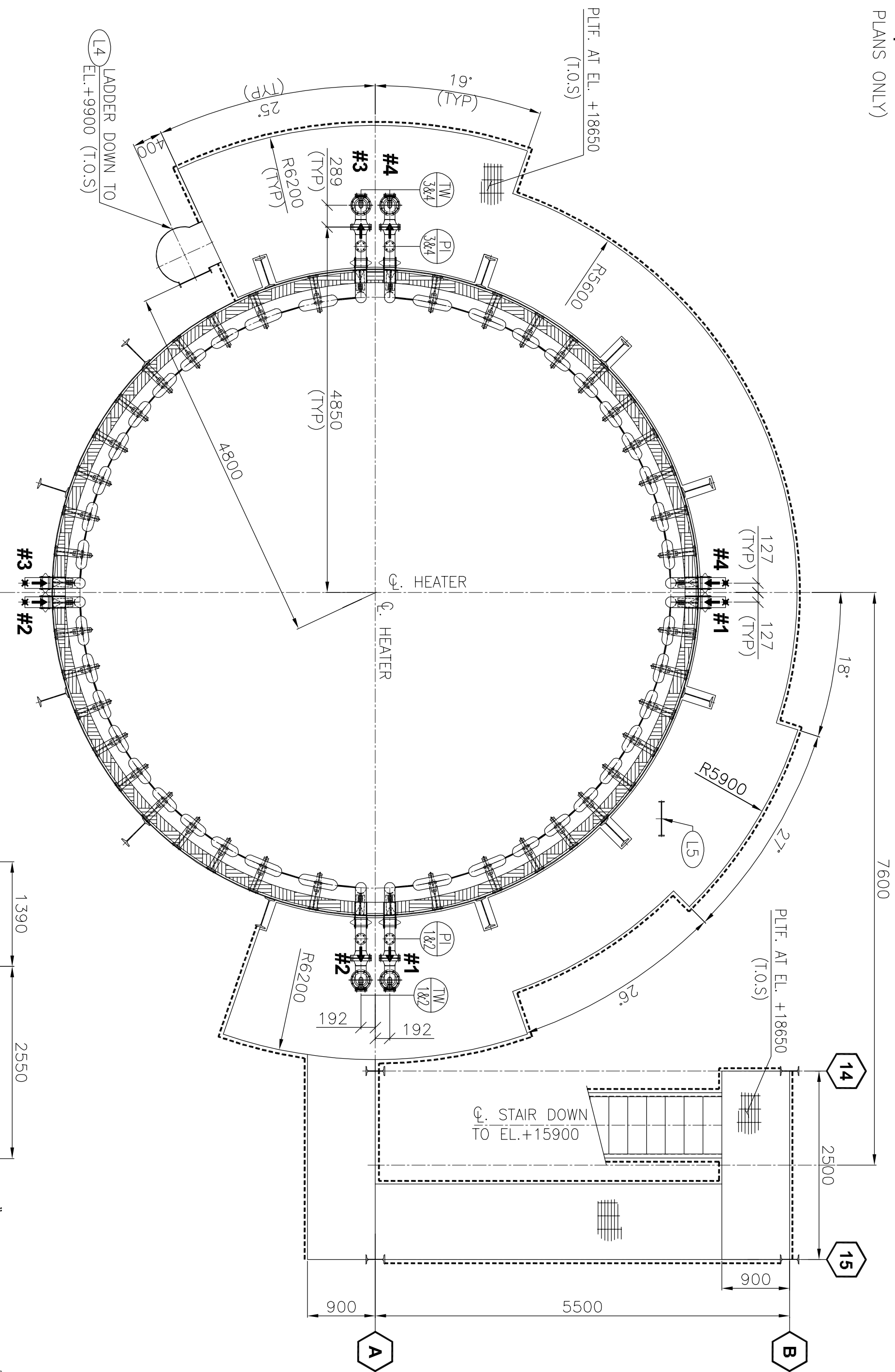
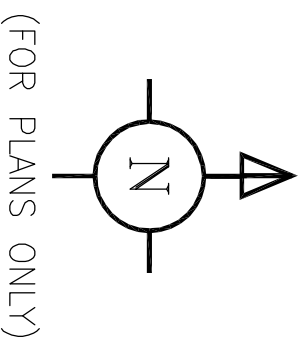


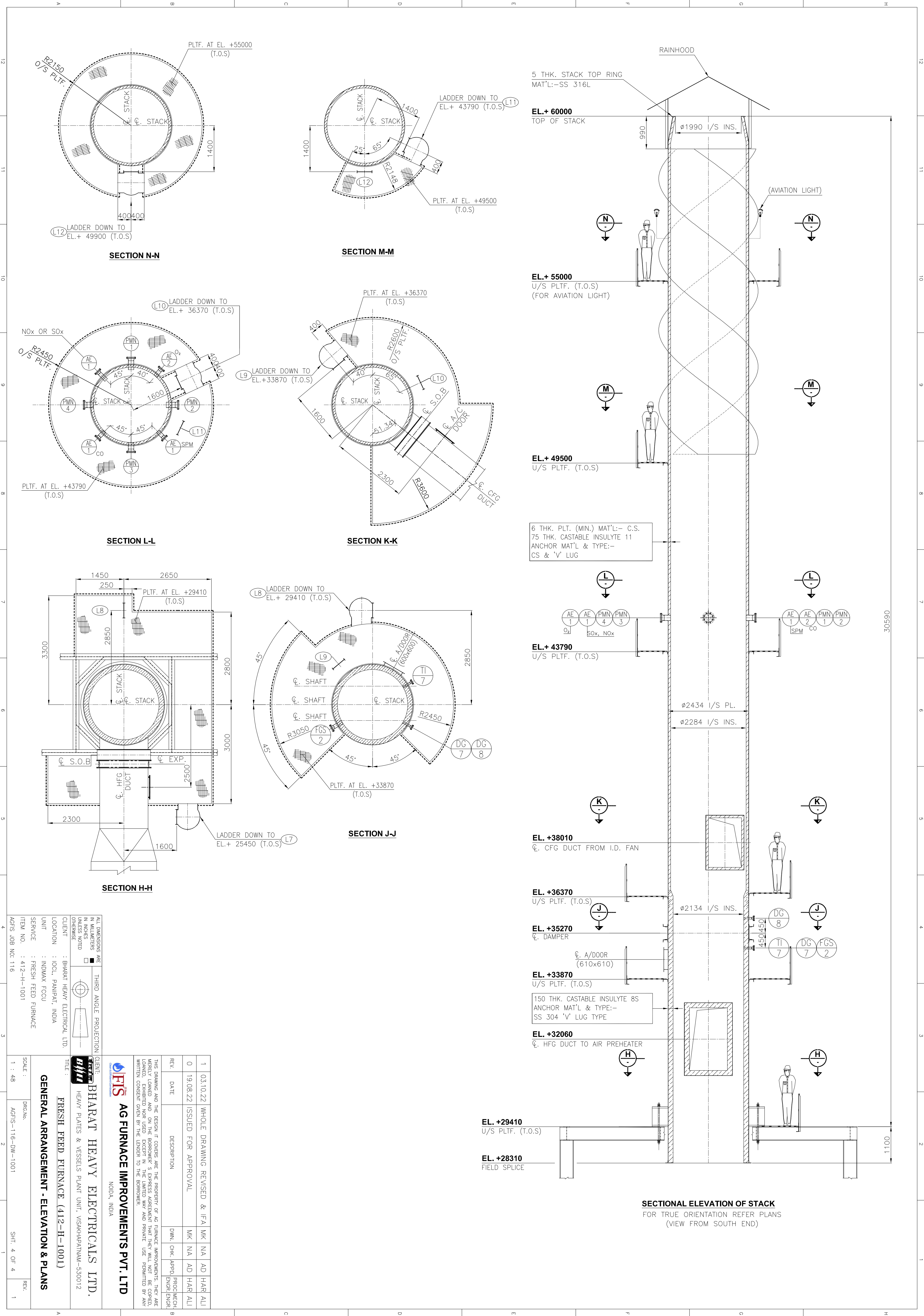
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Category Codes (Submission purpose)	tkIS - India / Owner / Client ☒ 1 For Approval ☐ 2 For Review / Comments ☐ 3 For Information ☐ 4 For Engineering ☐ 5 For Enquiry ☐ 6 For Order Placement ☐ 7 Final & Approved ☐ 8 Released for Construction
	tkIS - India / Owner / Client ☐ 1 Approved ☐ 2 Approved for Manufacturing/ Fabrication With Comments as Marked ☐ 3 Not Approved/Resubmit ☐ 4 Retained for Information/Records ☐ 5 Reviewed ☐ 6 Reviewed as Noted/Resubmit
	Acceptance Codes (Approval Codes)
	Date : / / Name : _____

Rev.	Date	Name	Date	Name	Date	Name	Description
	Drawn/Prepared		Checked		Approved		
Contract No.			Document ID			Part	Re
66-6745			6745-PRC-412-DZ-0002-032			FOA/04	

Store Location: Server/Share \\p666745666745-ada			O.E.M. BHARAT HEAVY ELECTRICALS LTD HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012			
Store Location: Folder \\ACAD\\VTF\\LWDRG			E.S.C. AG FURNACE IMPROVEMENTS NOIDA, INDIA			
Store Name 6745-PRC-412-FB-XXXX						
Pro. Unit	Con. Unit	TON	Group	Order No.	Type of Document	Sheet
412		412-H-1001			DZ	3 OF 3

 INDIAN OIL CORPORATION LIMITED  				IndianOil		thyssenkrupp Industrial Solutions (India) 20	
Drawn				Date		Name	
Prepared				21.09.2022		CH.SATISH KUMAR	
Checked				21.09.2022		YSR / U.KIRAN	
Approved				21.09.2022		AVY RAMANA	
Scale		Cat. Code		Acc. Code		Status	
NTS						TITLE	
						FRESH FEED FURNACE (412-H-1001)	
						P&I DIAGRAM OF HEATER	





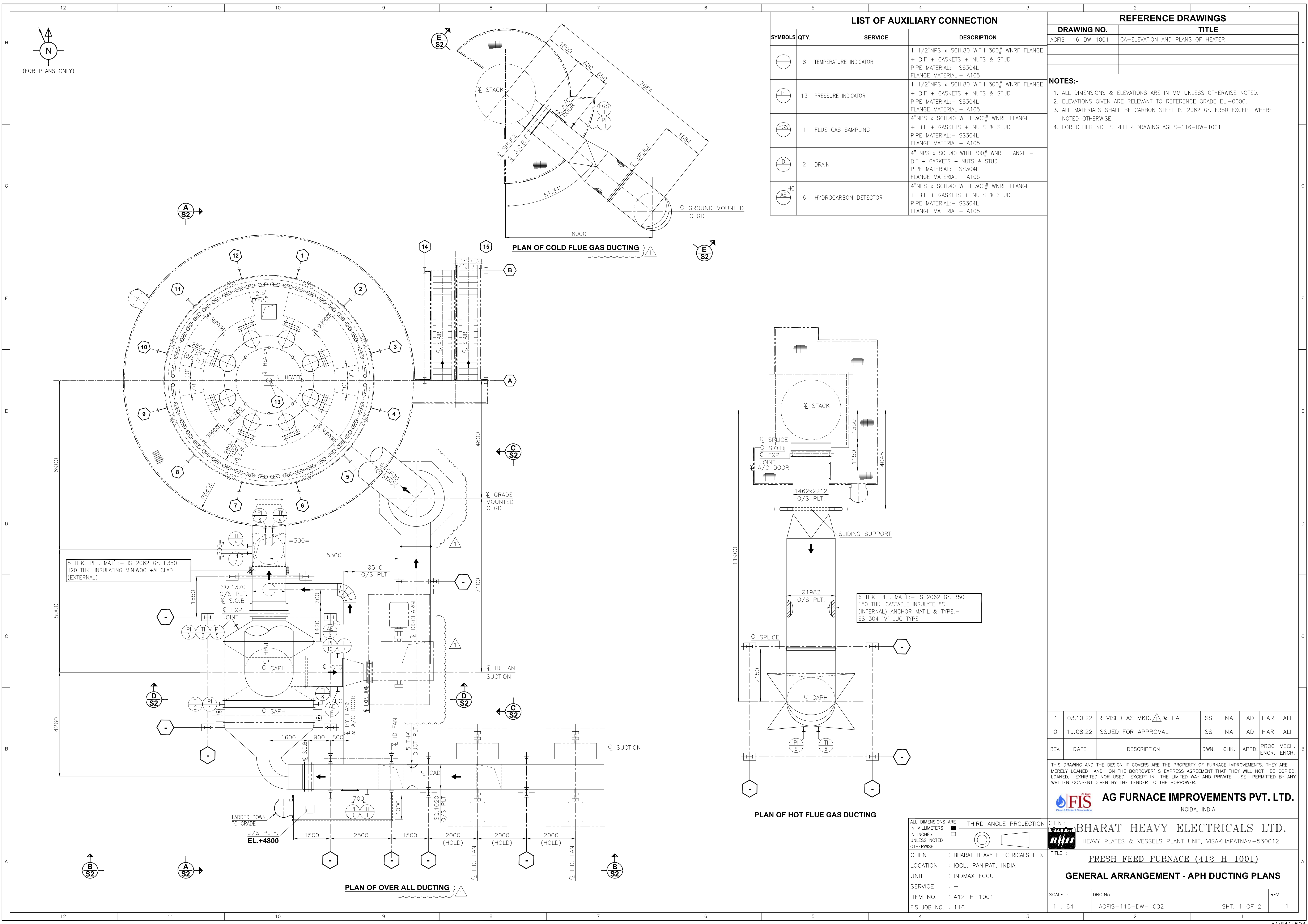
ALL DIMENSIONS ARE IN MILLIMETERS		THIRD ANGLE PROJECTION	
IN INCHES		BY	
OTHERWISE		BY	
CLIENT : BHARAT HEAVY ELECTRICALS LTD.		PROJECT : BHARAT HEAVY ELECTRICALS LTD.	
LOCATION : IOCL, PANIPAT, INDIA		UNIT : INDIAX FCCU	
SERVICE : FRESH FEED FURNACE		ITEM NO. : 412-H-1001	
AGFS JOB NO. 116		SCALE : 1 : 48	
		AGFS-116-DW-1001	
		SHT. 4 OF 4	
		REV. 1	

IFTS AG FURNACE IMPROVEMENTS PVT. LTD
NODA, INDIA

1	03.10.22	WHOLE DRAWING REVISED & IFA	MK	NA	AD	HAR	ALI
0	19.08.22	ISSUED FOR APPROVAL	MK	NA	AD	HAR	ALI
REV.	DATE	DESCRIPTION	DWN.	CHK.	APPD.	ENGR.	ENGR.

THIS DRAWING AND THE DESIGN IT COVERS ARE THE PROPERTY OF AG FURNACE IMPROVEMENTS. THEY ARE LOANED, LIBERATED AND NOT TO BE REPRODUCED OR USED IN ANY MANNER WITHOUT THE WRITTEN CONSENT OF THE BORROWER. ANY VIOLATION OF THIS AGREEMENT WILL BE PERMITTED BY ANY COURT OF LAW.

GENERAL ARRANGEMENT - ELEVATION & PLANS

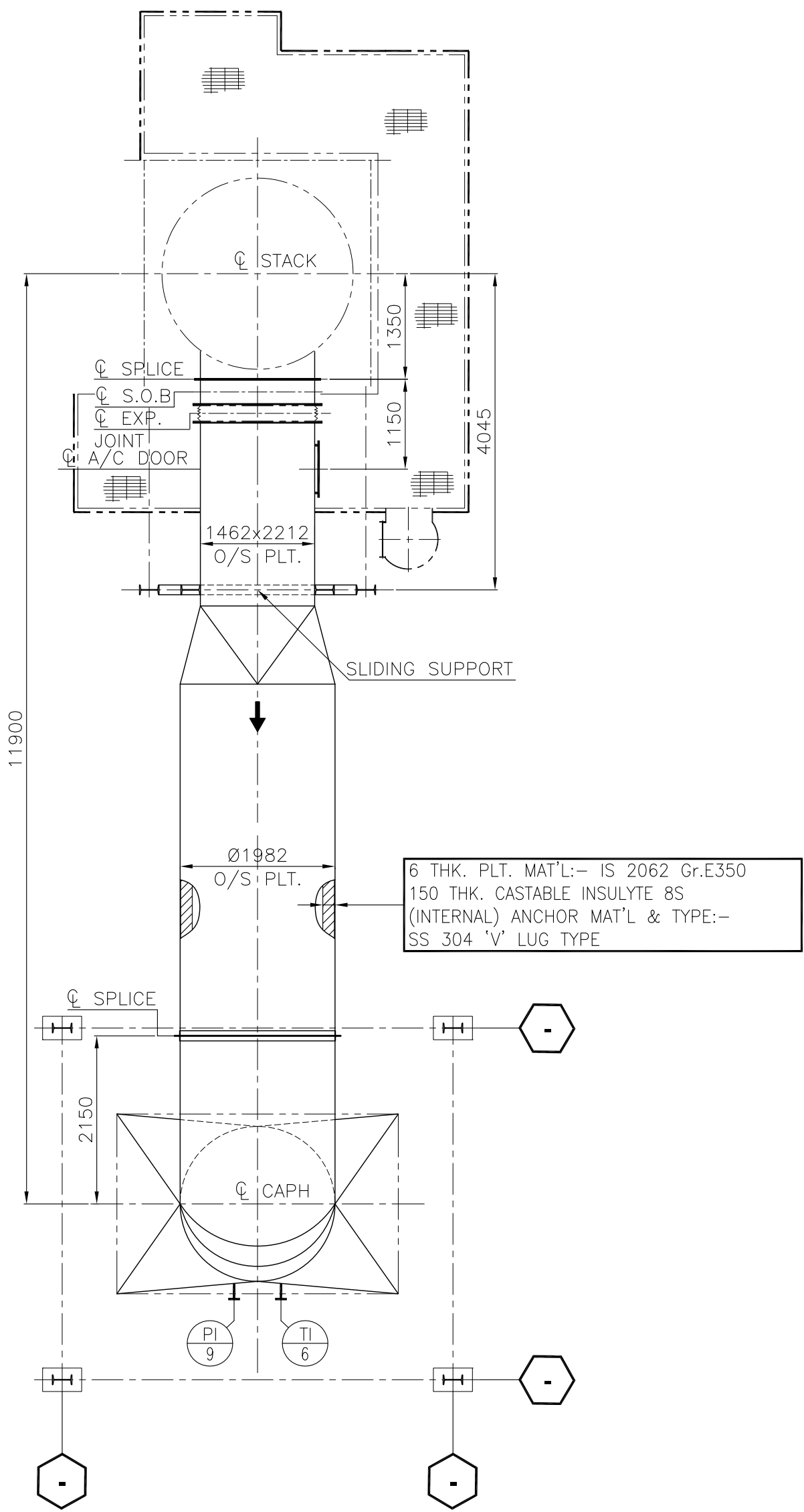


LIST OF AUXILIARY CONNECTION			
SYMBOLS	QTY.	SERVICE	DESCRIPTION
	8	TEMPERATURE INDICATOR	1 1/2"NPS x SCH.80 WITH 300# WNRF FLANGE + B.F + GASKETS + NUTS & STUD PIPE MATERIAL:- SS304L FLANGE MATERIAL:- A105
	13	PRESSURE INDICATOR	1 1/2"NPS x SCH.80 WITH 300# WNRF FLANGE + B.F + GASKETS + NUTS & STUD PIPE MATERIAL:- SS304L FLANGE MATERIAL:- A105
	1	FLUE GAS SAMPLING	4"NPS x SCH.40 WITH 300# WNRF FLANGE + B.F + GASKETS + NUTS & STUD PIPE MATERIAL:- SS304L FLANGE MATERIAL:- A105
	2	DRAIN	4" NPS x SCH.40 WITH 300# WNRF FLANGE + B.F + GASKETS + NUTS & STUD PIPE MATERIAL:- SS304L FLANGE MATERIAL:- A105
	6	HYDROCARBON DETECTOR	4"NPS x SCH.40 WITH 300# WNRF FLANGE + B.F + GASKETS + NUTS & STUD PIPE MATERIAL:- SS304L FLANGE MATERIAL:- A105

REFERENCE DRAWINGS	
DRAWING NO.	TITLE
AGFIS-116-DW-1001	GA-ELEVATION AND PLANS OF HEATER

NOTES:-

1. ALL DIMENSIONS & ELEVATIONS ARE IN MM UNLESS OTHERWISE NOTED.
2. ELEVATIONS GIVEN ARE RELEVANT TO REFERENCE GRADE EL.+0000.
3. ALL MATERIALS SHALL BE CARBON STEEL IS-2062 Gr. E350 EXCEPT WHERE NOTED OTHERWISE.
4. FOR OTHER NOTES REFER DRAWING AGFIS-116-DW-1001.



PLAN OF HOT FLUE GAS DUCTING

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE		THIRD ANGLE PROJECTION	
CLIENT : BHARAT HEAVY ELECTRICALS LTD.		LOCATION : IOCL, PANIPAT, INDIA	
UNIT : INDMAX FCCU		SERVICE : -	
ITEM NO. : 412-H-1001		FIS JOB NO. : 116	

1	03.10.22	REVISED AS MKD. & IFA	SS	NA	AD	HAR	ALI
0	19.08.22	ISSUED FOR APPROVAL	SS	NA	AD	HAR	ALI
REV.	DATE	DESCRIPTION	DWN.	CHK.	APPD.	PROC. ENGR.	MECH. ENGR.

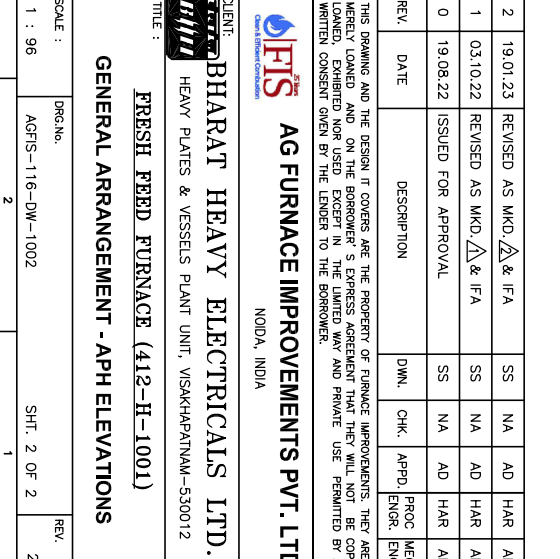
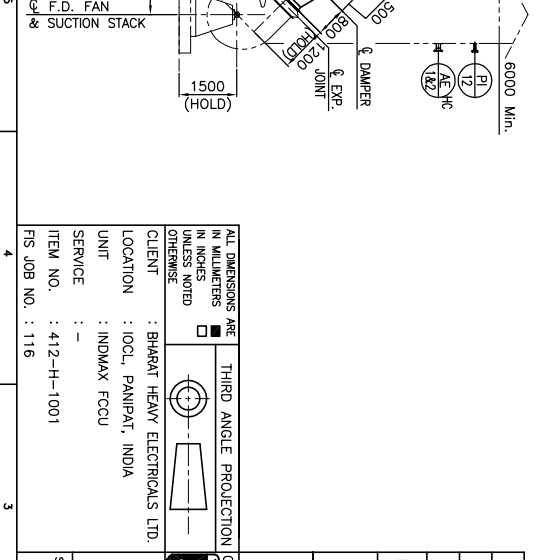
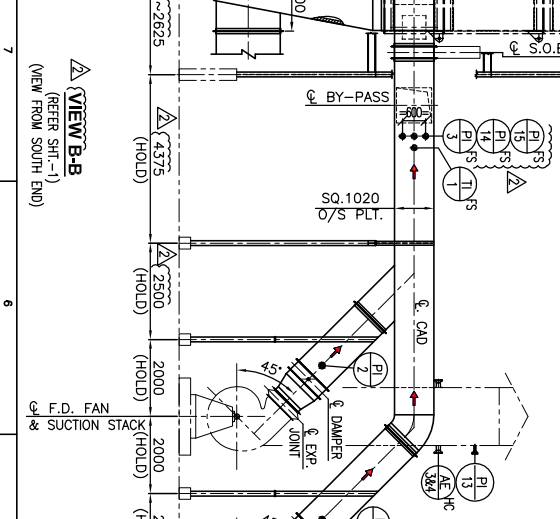
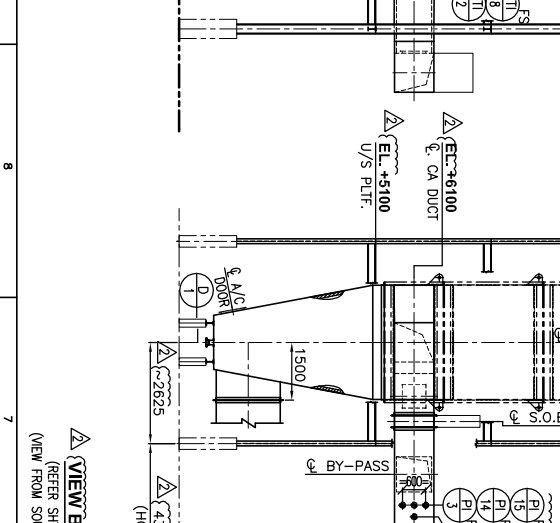
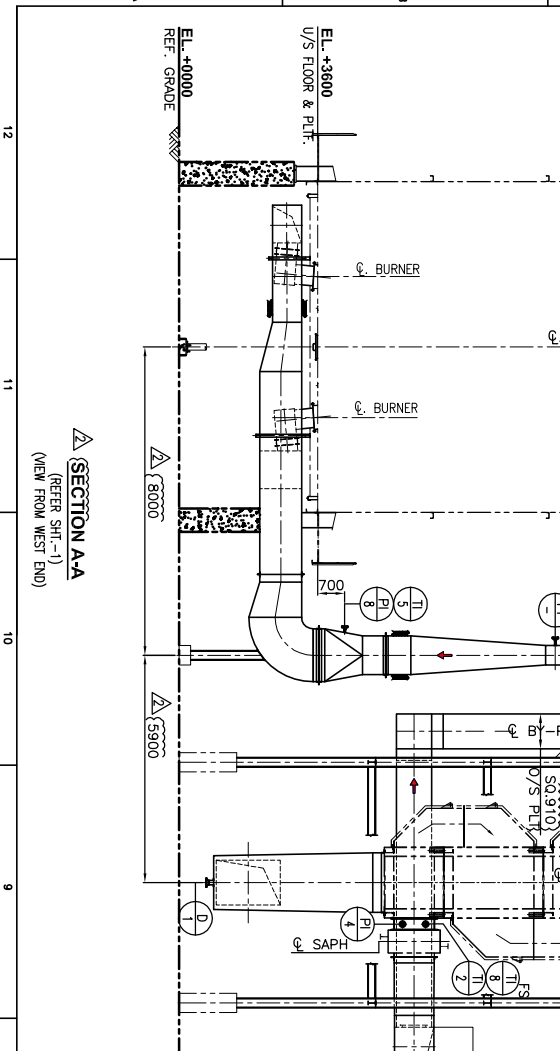
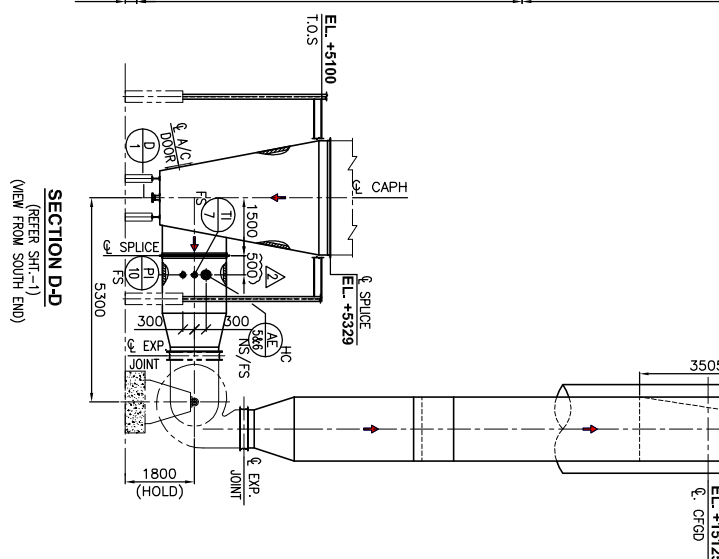
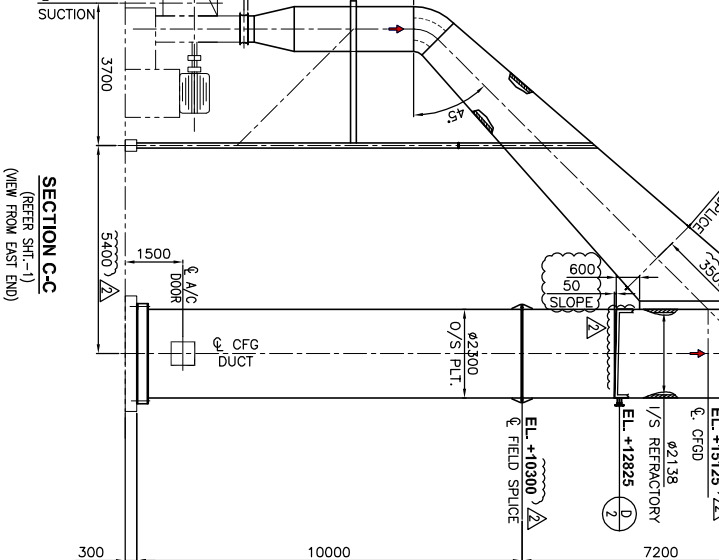
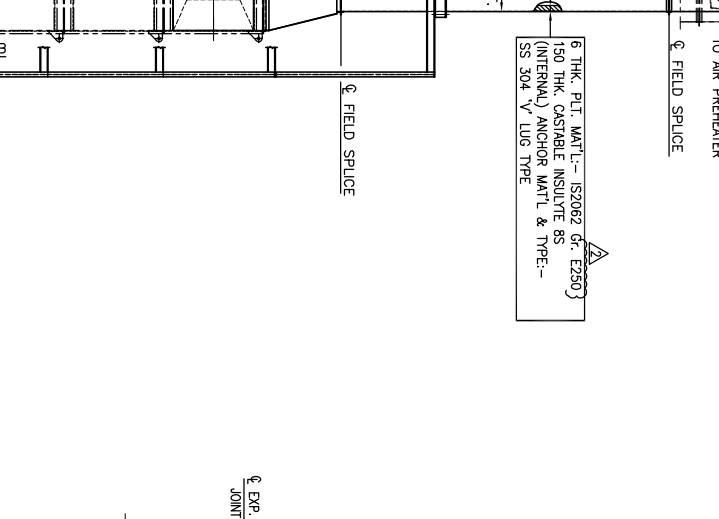
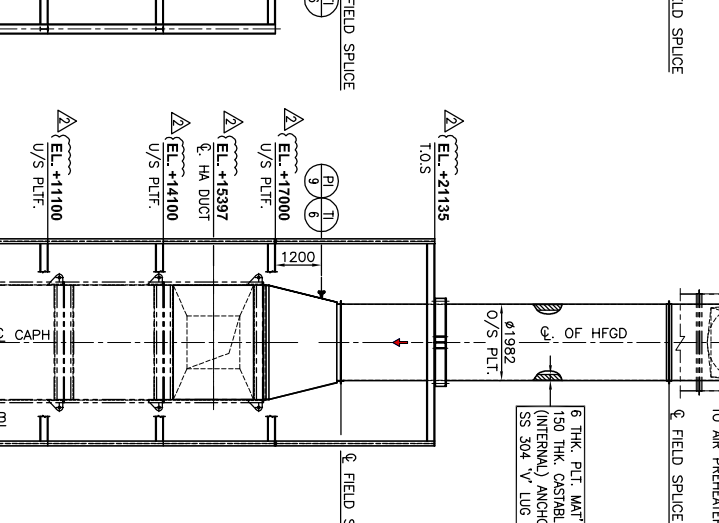
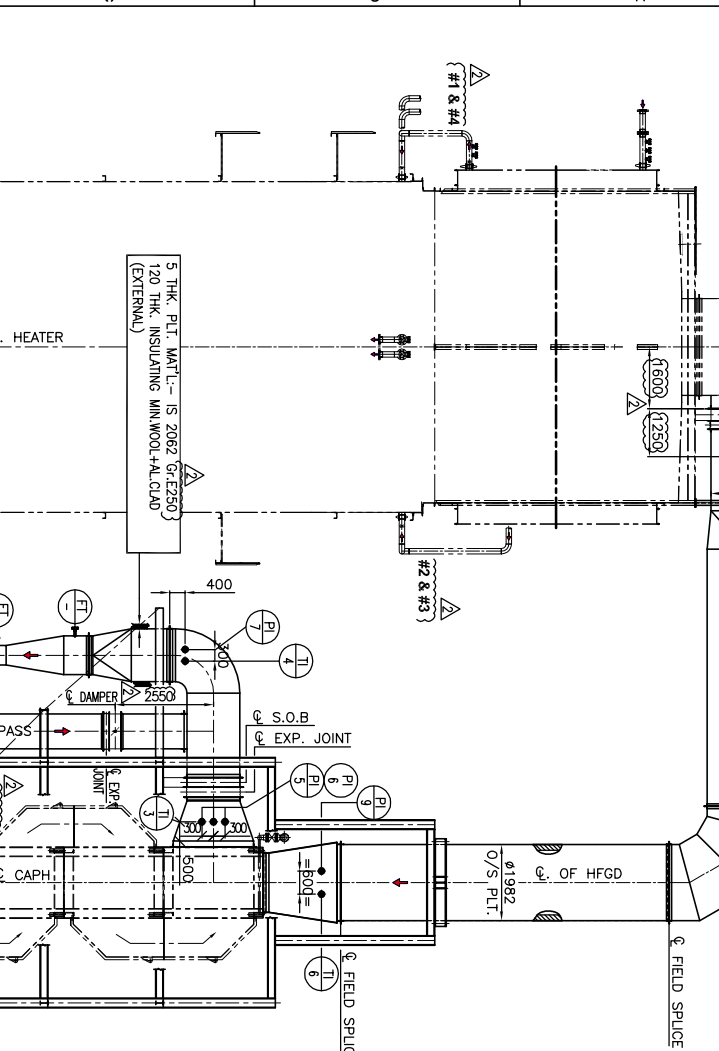
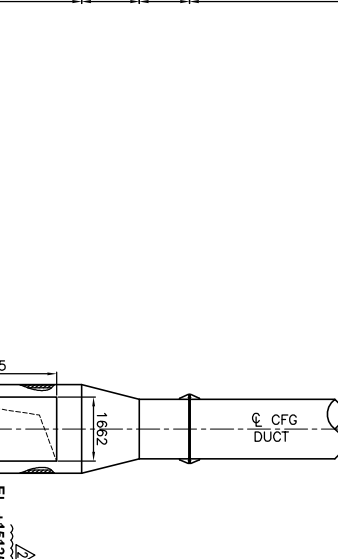
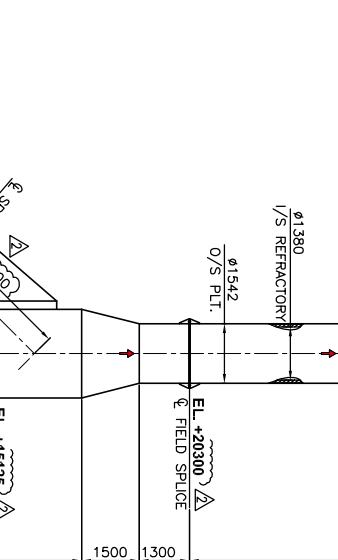
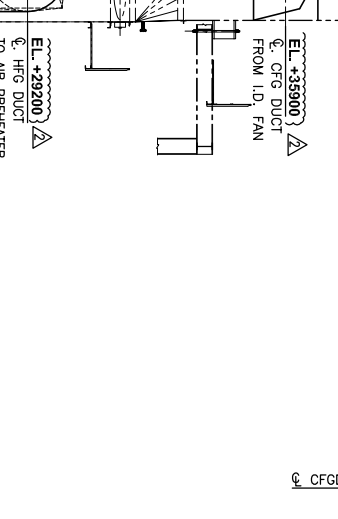
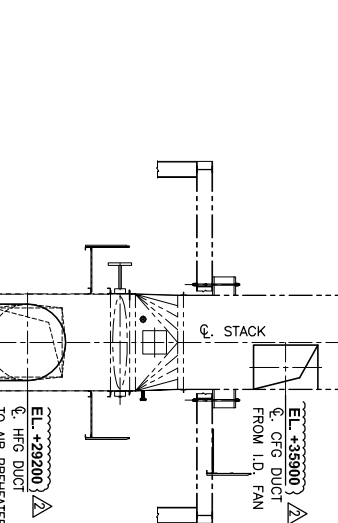
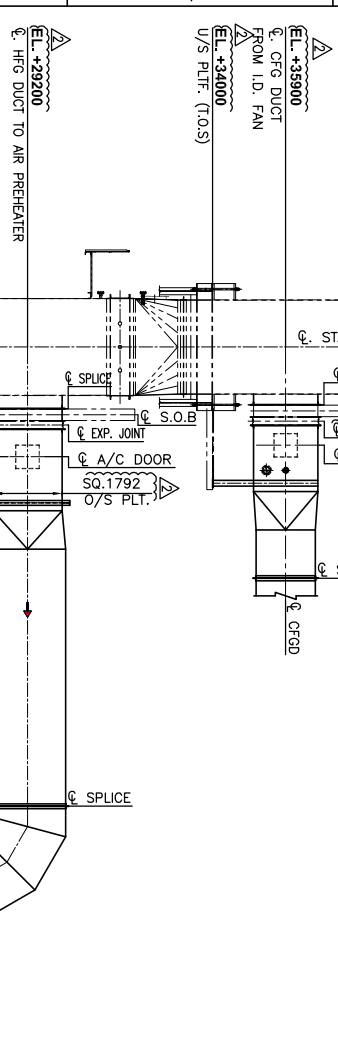
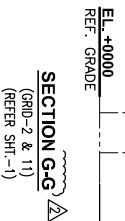
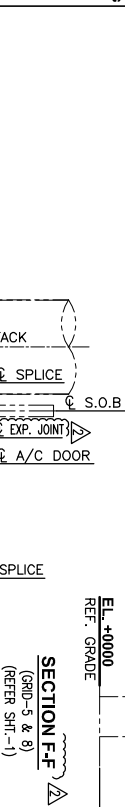
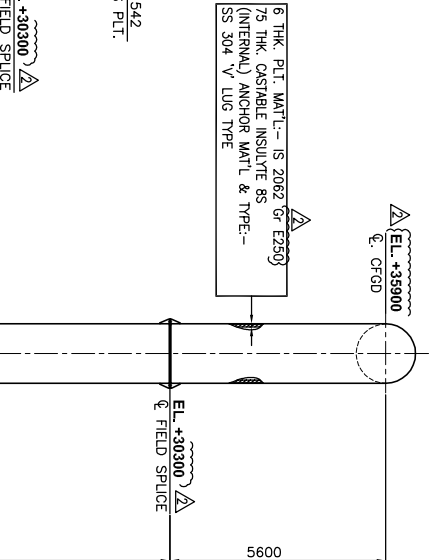
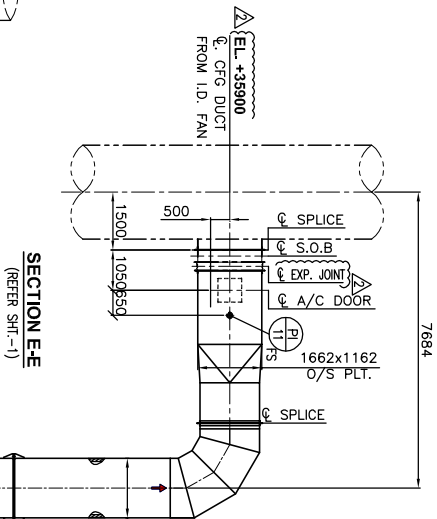
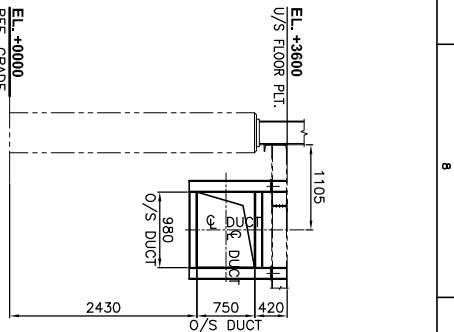
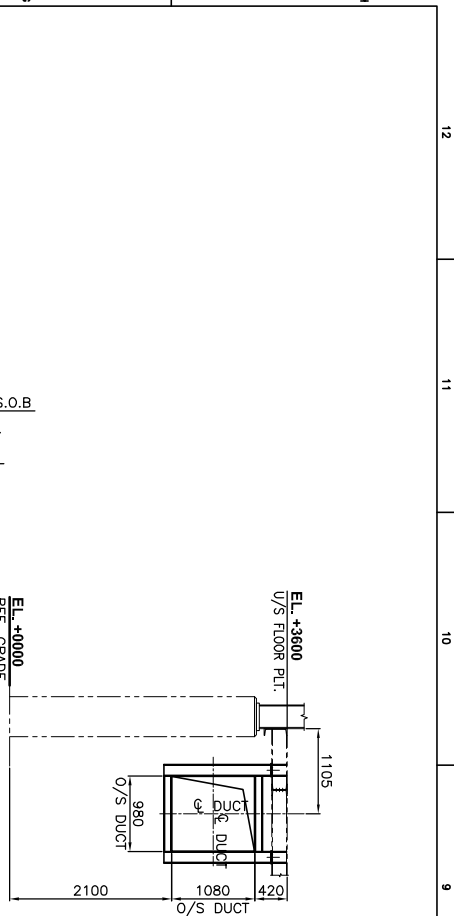
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FIS AG FURNACE IMPROVEMENTS PVT. LTD.
NOIDA, INDIA

CLIENT: **BHARAT HEAVY ELECTRICALS LTD.**
HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012

TITLE : **FRESH FEED FURNACE (412-H-1001)**
GENERAL ARRANGEMENT - APH DUCTING PLANS

SCALE :	DRG.No.	REV.
1 : 64	AGFIS-116-DW-1002	SHT. 1 OF 2



ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE		THIRD ANGLE PROJECTION		CLIENT : BHARAT HEAVY ELECTRICALS LTD.	
LOCATION : IOCL, PANIPAT, INDIA		UNIT : INDIA		TITLE : FRESH FEED FURNACE (412-H-1001)	
SERVICE : -		ITEM NO. : 412-H-1001		GENERAL ARRANGEMENT - APH ELEVATIONS	
FIS JOB NO. : 116		SCALE : 1 : 96		REV. 2	
A/FIS-116-DW-1002		SHT. 2 OF 2		REV. 2	

REV. 2		19.01.23		REVISED AS MKD. & IFA		SS	NA	AD	HAR	AI
1		03.10.22		REVISED AS MKD. & IFA		SS	NA	AD	HAR	AI
0		19.08.22		ISSUED FOR APPROVAL		SS	NA	AD	HAR	AI
REV. DATE		DESCRIPTION		DNL		CHK.	APPD.	ENGR.	ENGR.	
2		19.01.23		REVISED AS MKD. & IFA		SS	NA	AD	HAR	AI
1		03.10.22		REVISED AS MKD. & IFA		SS	NA	AD	HAR	AI
0		19.08.22		ISSUED FOR APPROVAL		SS	NA	AD	HAR	AI
REV. DATE		DESCRIPTION		DNL		CHK.	APPD.	ENGR.	ENGR.	

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CLIENT : BHARAT HEAVY ELECTRICALS LTD.
HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012

AG FURNACE IMPROVEMENTS PVT. LTD.
NODIA, INDIA

GENERAL ARRANGEMENT - APH ELEVATIONS

SCALE : 1 : 96

A/FIS-116-DW-1002

SHT. 2 OF 2

REV. 2

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NODIA, INDIA

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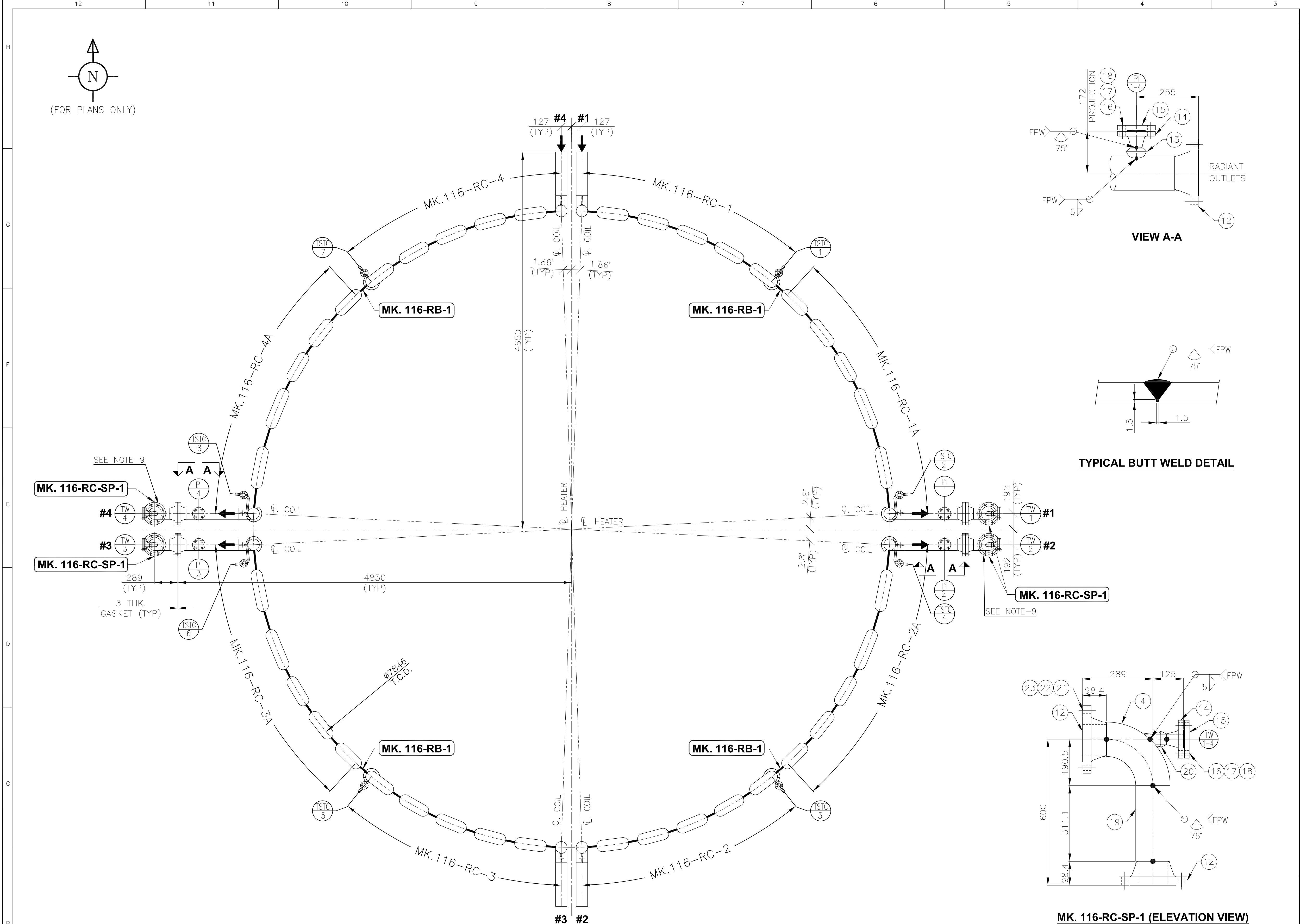
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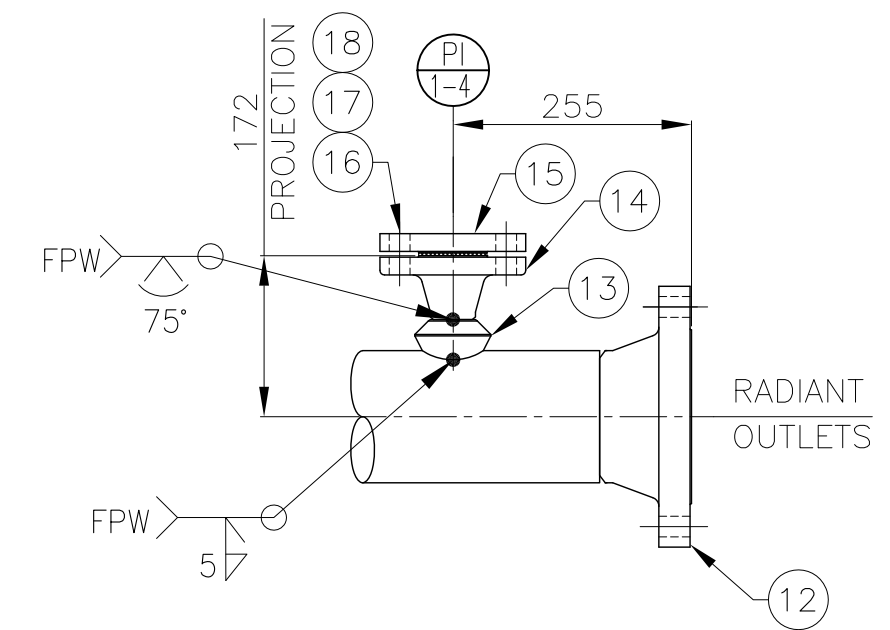
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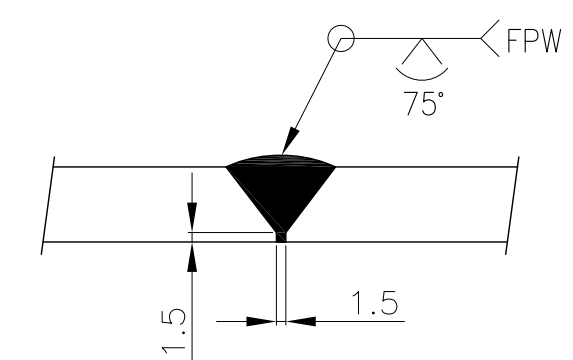
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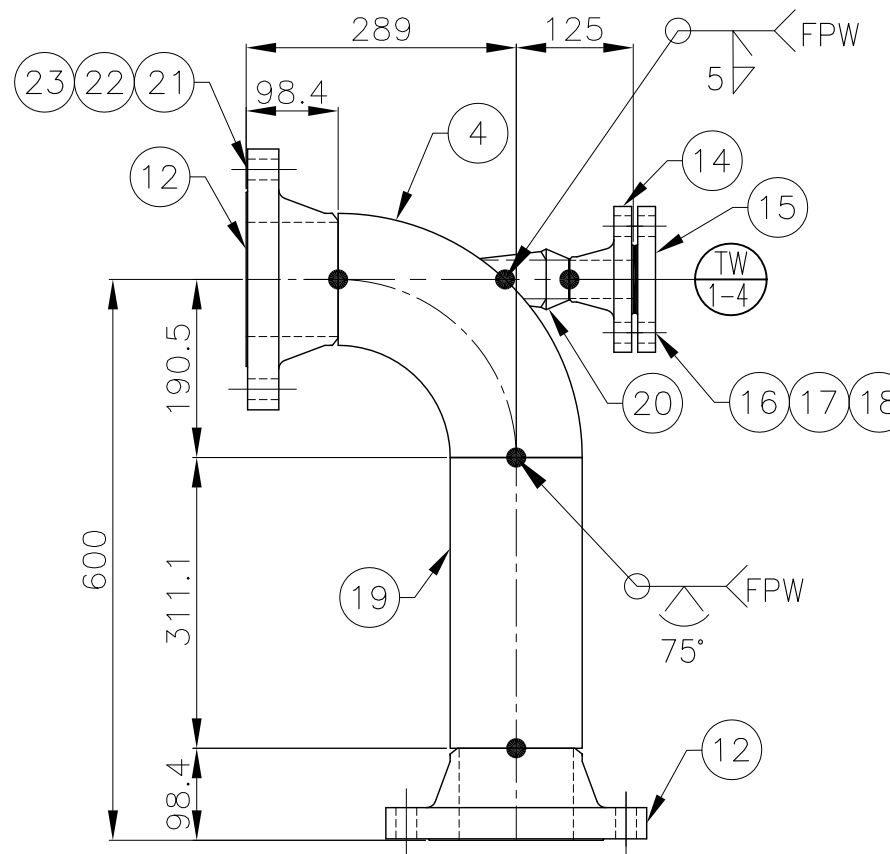
PLAN VIEW OF RADIANT COIL



VIEW A-A



TYPICAL BUTT WELD DETAIL



MK. 116-RC-SP-1 (ELEVATION VIEW)
(4 NOS. REQUIRED)

DESIGN CONDITIONS	
DESIGN CODE (TUBE)	API 530
DESIGN PRESSURE, ELASTIC/RUPTURE, (KG/CM ²)(G)	29.5
DESIGN FLUID TEMP. (°C)	390
DESIGN TUBE METAL TEMP. (°C)	502
SHOP HYDROTEST PRESSURE (KG/CM ²)	63
FIELD HYDROTEST PRESSURE (KG/CM ²)	63
CORROSION ALLOWANCE-COIL(MM)	3
RADIOGRAPHY: (ALL PRESSURE PART)	100%
POST WELD HEAT TREATMENT	YES

PROCESS CONNECTION					CONNECTION: MAX. ALLOWABLE FORCE (N), MOMENTS (N.m) (5 x API 560)						MAXIMUM ALLOWABLE MOVEMENTS (mm)			SIGN CONVENTION FOR TERMINAL MOVEMENTS AND LOADS.
ITEM	QTY.	DESIGNATION	MATERIAL	ELEVATION	F _x	F _y	F _z	M _x	M _y	M _z	X	Y	Z	
OUTLETS	4	5" NPS x SCH.40 300# RFWN FLANGE	A182 Gr.F9	EL.+20286	5005	10010	10010	4475	3390	3390	0	±25	±25	

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE		THIRD ANGLE PROJECTION	
CLIENT : BHARAT HEAVY ELECTRICALS LTD.		LOCATION : IOCL, PANIPAT, INDIA	
UNIT : INDMAX FCCU		SERVICE : FRESH FEED FURNACE	
ITEM NO. : 412-H-1001		AGFIS JOB NO.: 116	

REFERENCE DRAWINGS	
DRAWING NO.	TITLE
AGFIS-116-DW-1001	GENERAL ARRANGEMENT-ELEVATION AND PLANS
AGFIS-116-DW-1006	DETAILS OF X-OVER

- NOTES :-**
- DO NOT SCALE THE DRAWING, ASK IF IN DOUBT.
 - ALL DIMENSIONS AND UNITS ARE IN THE MKS SYSTEM, U.N.O.
 - ELEVATIONS GIVEN ARE RELEVANT TO REF. GRADE EL+0000.
 - ALL ITEMS SHALL BE CHECKED BY FULL SCALE LAYOUT BEFORE FABRICATION.
 - NO UNDER CUT OF PIPE WALL IS PERMITTED DUE TO WELDING.
 - COMPLETED ASSEMBLIES TO BE SHOP HYDRO TESTED AFTER COMPLETION OF WELDING AND ALL STATED INSPECTION REQUIREMENTS.
 - COIL SHALL BE DRIED AFTER HYDROTEST.
 - ALL WELD PREPARATION SHALL CONFORM TO ANSI B16.25.
 - ALL FLANGE BOLT HOLES SHALL STRADDLE NATURAL CENTER LINES.
 - ALL COIL WELDS MUST BE FULL PENETRATION TYPE.
 - ALL PIPES AND FITTINGS SHALL BE SEAMLESS TYPE.
 - PWHT SHALL BE CARRIED OUT ON PRESSURE PART WELD AS PER PROJECT SPEC.
 - 100% RT REQUIRED FOR ALL WELDS AFTER PWHT.
 - 100% PMI TESTING REQUIRED ON ALLOY PRESSURE PART WELDS INCLUDING WELD FILLER MATERIALS.
 - GENERAL ENGINEERING SPECIFICATION FOR FIRED HEATER DOC. NO. 6745-PRC-000-EC-003.
 - EIL ENGINEERING DESIGN BASIS (PART-B) DOC. NO. B269-999-02-42-ODB-1001.
 - ENGINEERING DESIGN BASIS FIRED HEATER EQUIPMENT MECHANICAL DOC. NO. B269-999-80-44-EDB-1001.
 - TECHNICAL SPECIFICATION FOR PIPE, FITTING, FLANGES, GASKET & FASTENERS DOC. NO. 6745-PIP-EC-0001.
 - EIL STANDARD SPECIFICATION OF COIL WORK FOR FIRED HEATERS. DOC. NO. 6-17-0003.
 - SPECIFICATION FOR POSITIVE IDENTIFICATION (PMI) AT SUPPLIER'S WORK DOC. NO. 6745-PIP-EC-0006.
 - THERE ARE TOTAL OF 88 TUBES IN 4 PASSES IN RADIANT SECTION. LAST 4 TUBES IN EACH PASS ARE SPACED AT 3D PITCH (381 MM) ON EITHER SIDES. BALANCE TUBES ARE SPACED AT 2D PITCH (254 MM) WITH D BEING NOMINAL DIA. OF TUBE.
 - PIPES WITH FIELD WELDS SHALL HAVE 25mm EXTRA LENGTH TO PERMIT WELDING OF CAP/BLIND FOR HYDRO TEST. THE EXTRA LENGTH SHALL BE TRIMMED AFTER HYDRO-TEST AND PROVIDED WITH WELD BEVELS.

BBE	:	BEVELED ON BOTH ENDS
●	:	INDICATES SHOP WELD
✕	:	INDICATES FIELD WELD
FPW	:	FULL PENETRATION WELD
EL	:	ELEVATION
C/C	:	CENTER TO CENTER
CL	:	CENTER LINE

1	11.10.22	WHOLE DRAWING REVISED & IFA	AJ	NA	NA	ALI	AD
0	26.08.22	ISSUED FOR APPROVAL	SA	MK	NA	ALI	AD
REV.	DATE	DESCRIPTION	DWN.	CHK.	APPD.	MECH. ENGR.	PROJ. MGR.

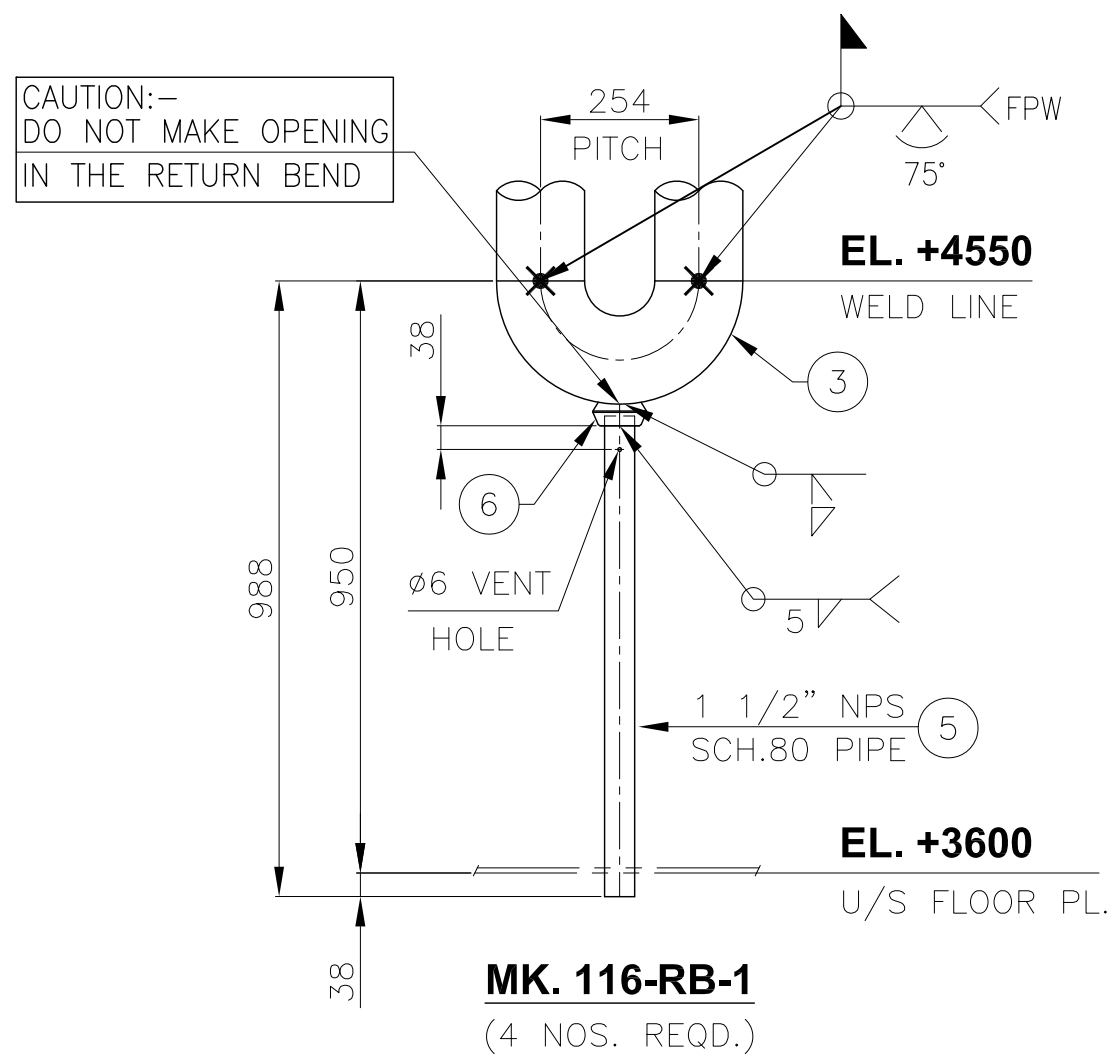
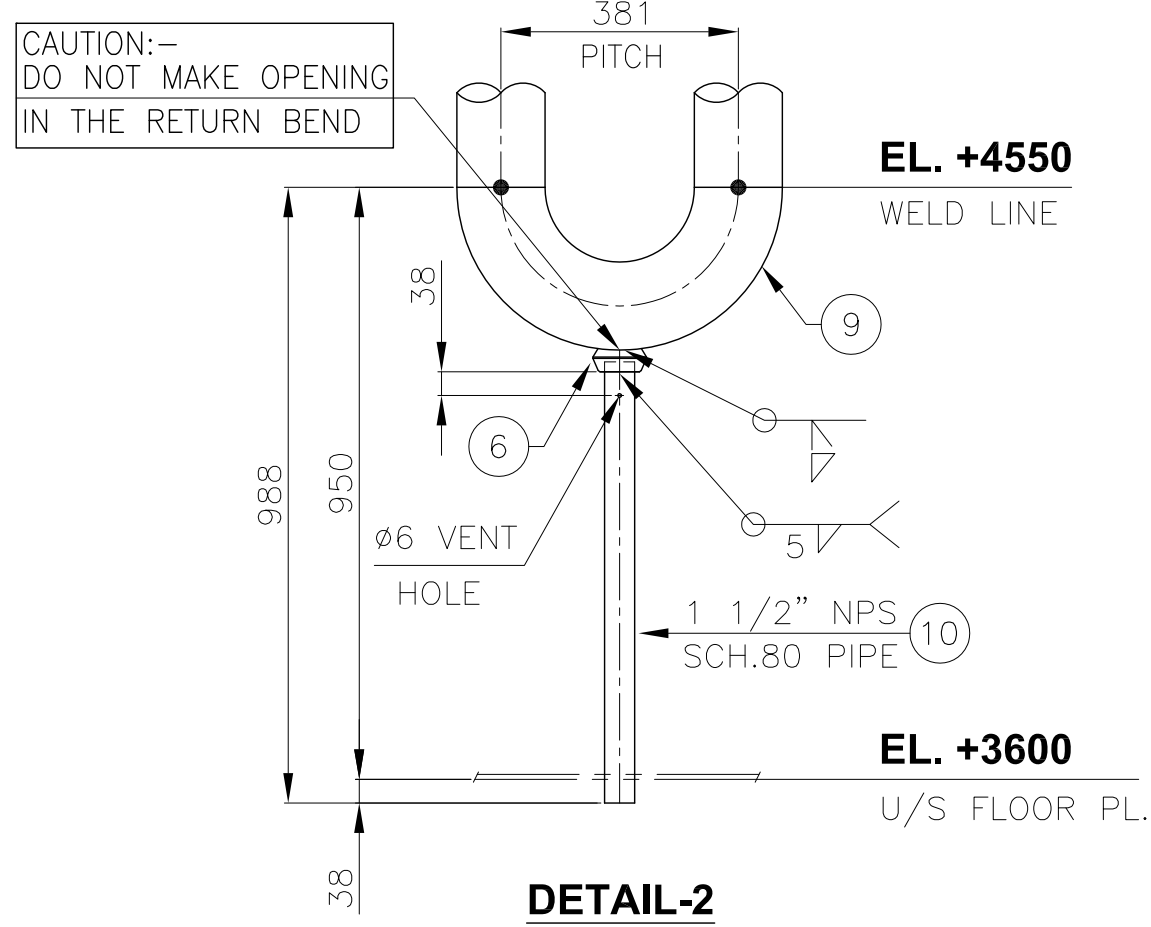
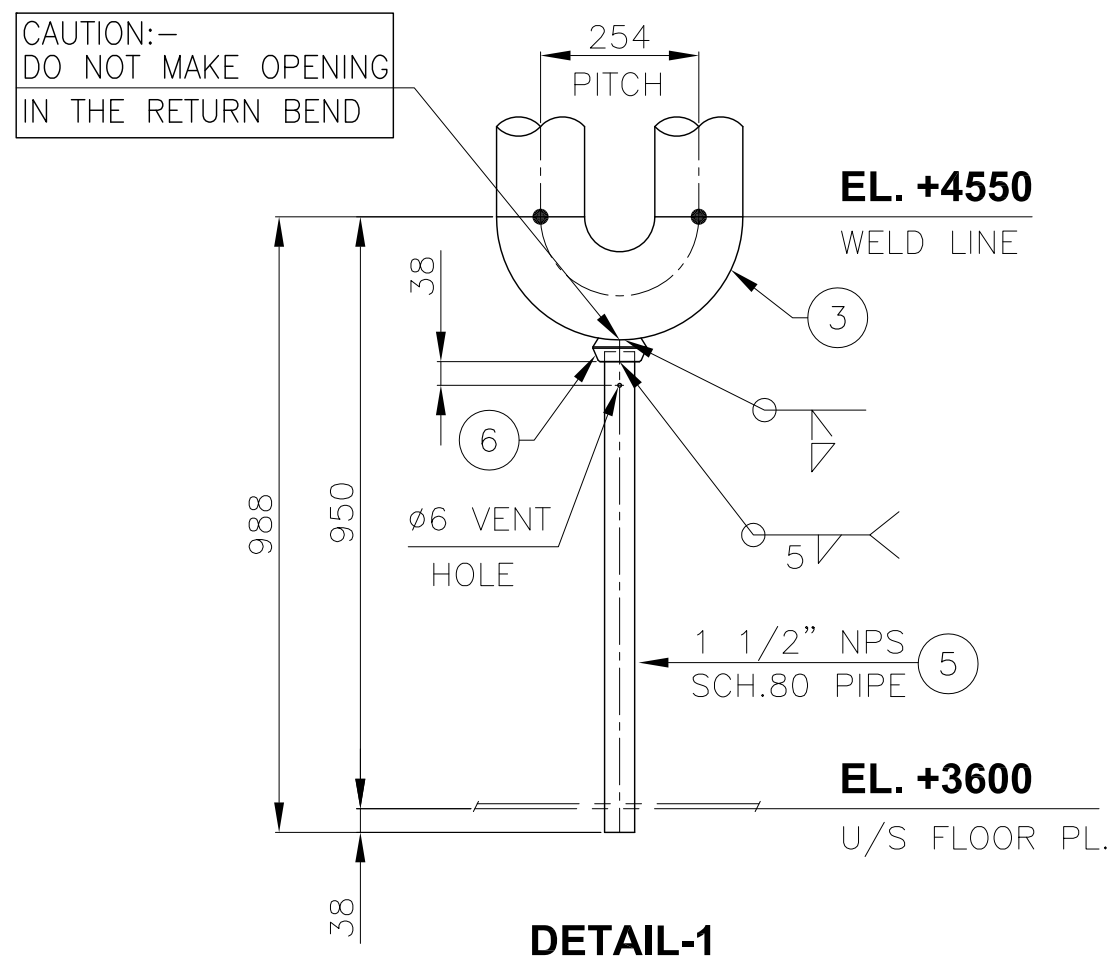
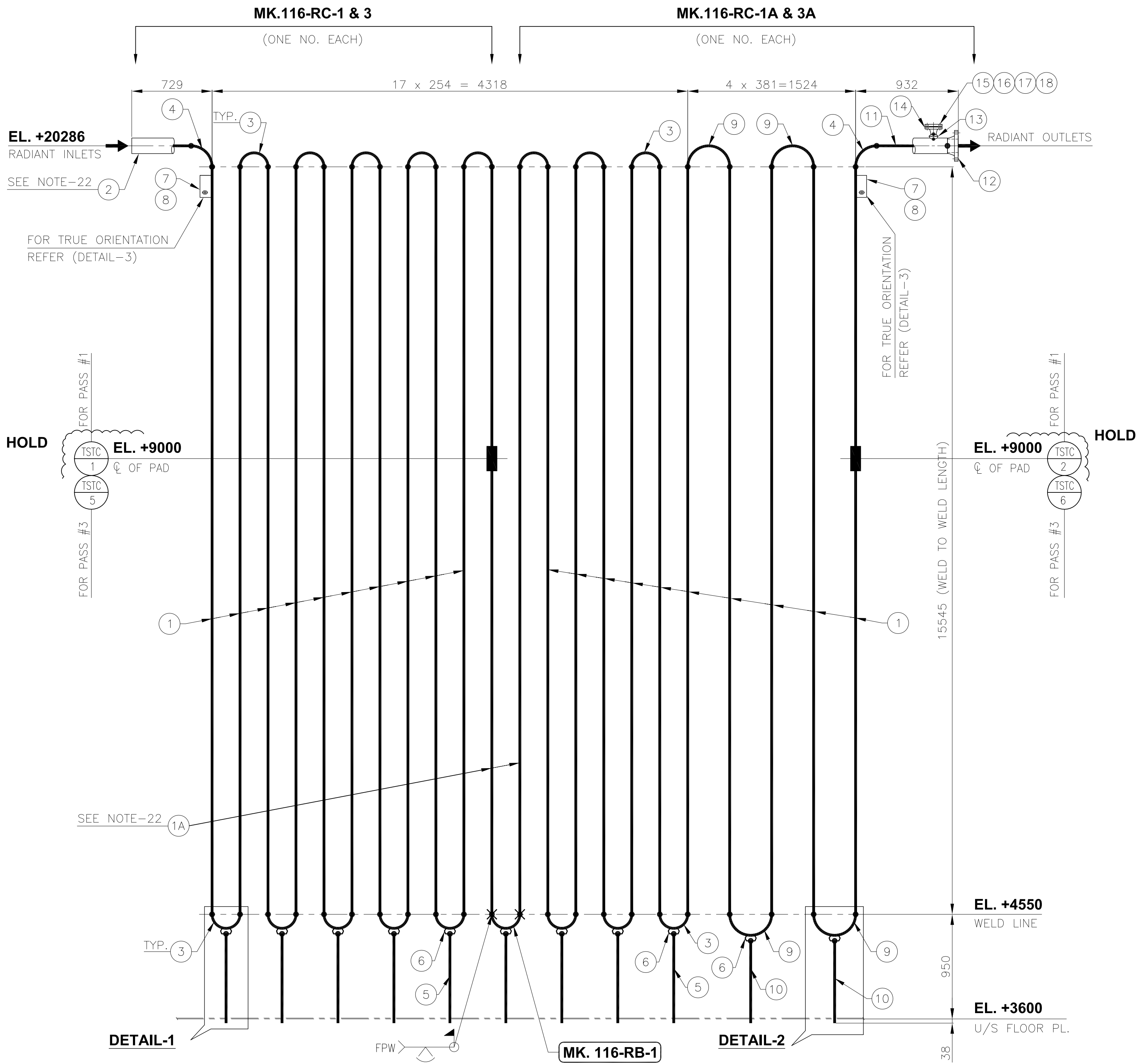
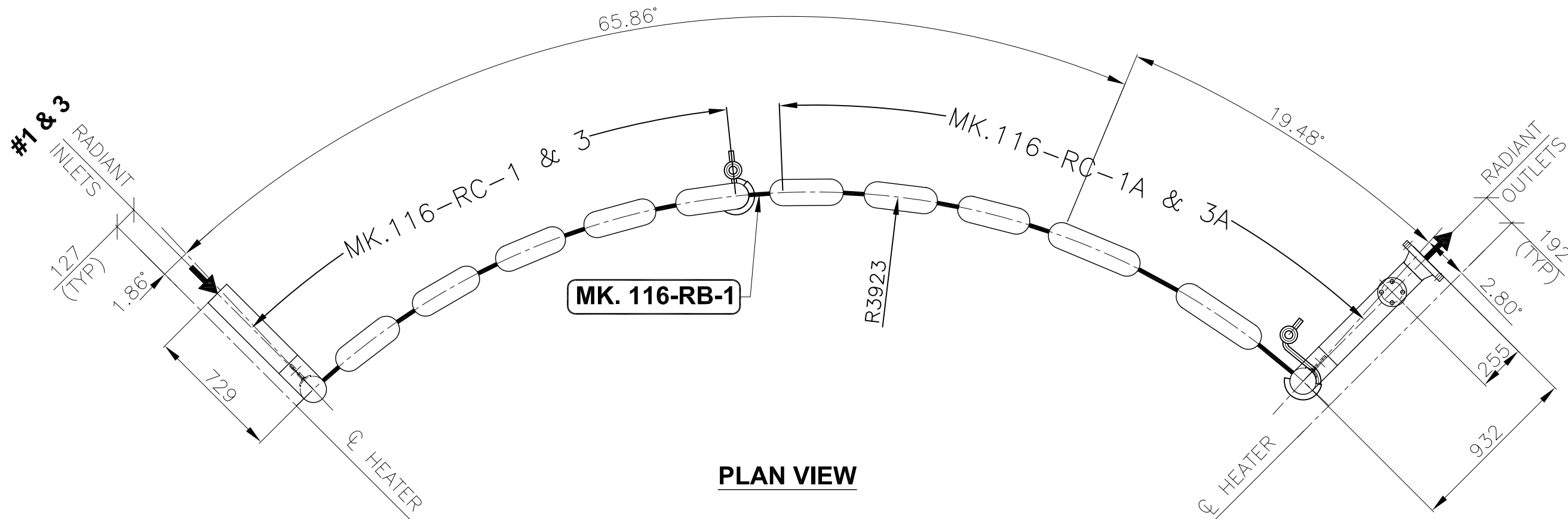
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AG FURNACE IMPROVEMENTS PVT. LTD
Noida, India

CLIENT: **BHARAT HEAVY ELECTRICALS LTD.**
HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012

TITLE : **FRESH FEED FURNACE (412-H-1001)**
DETAILS OF RADIANT COILS

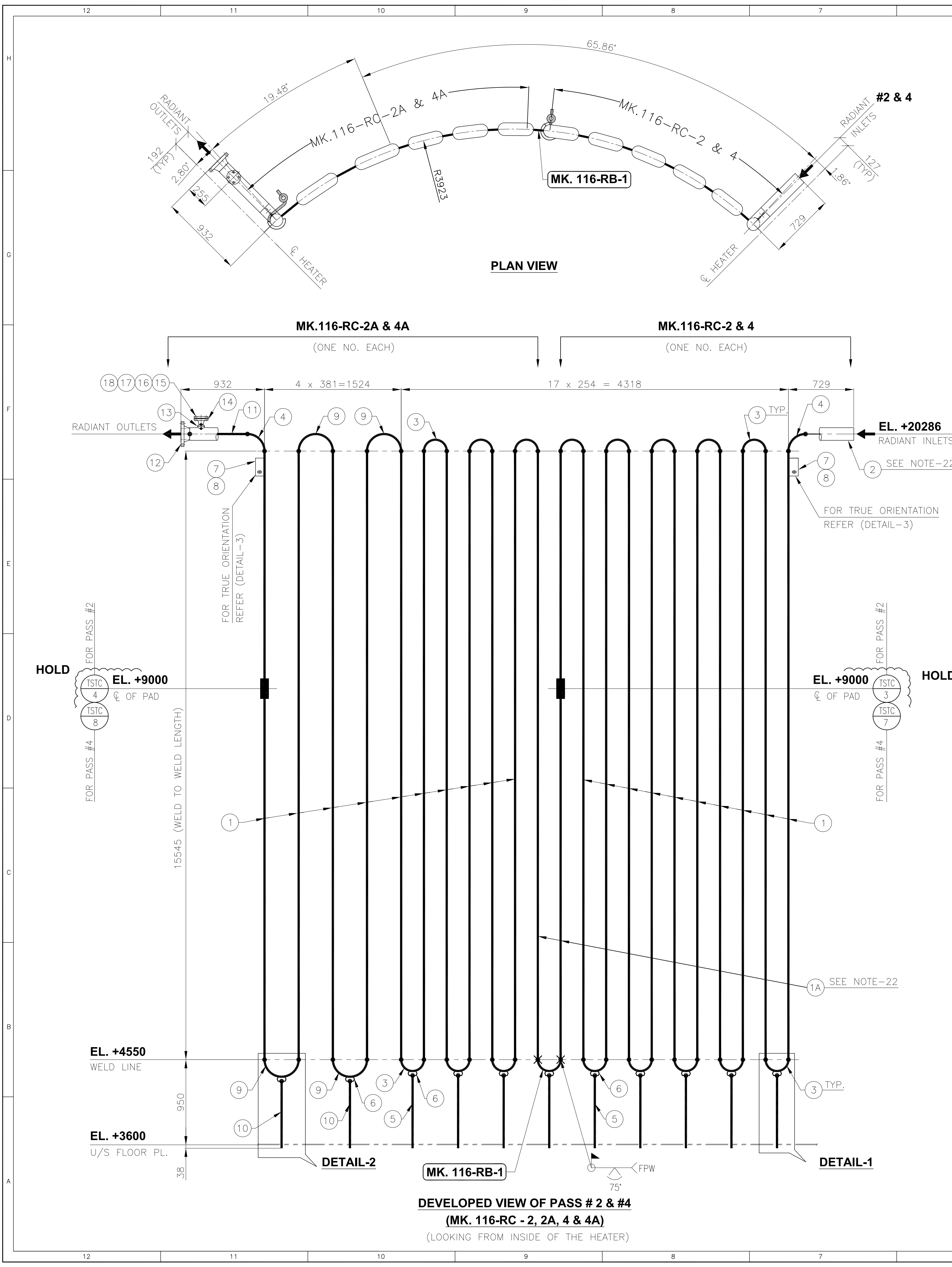
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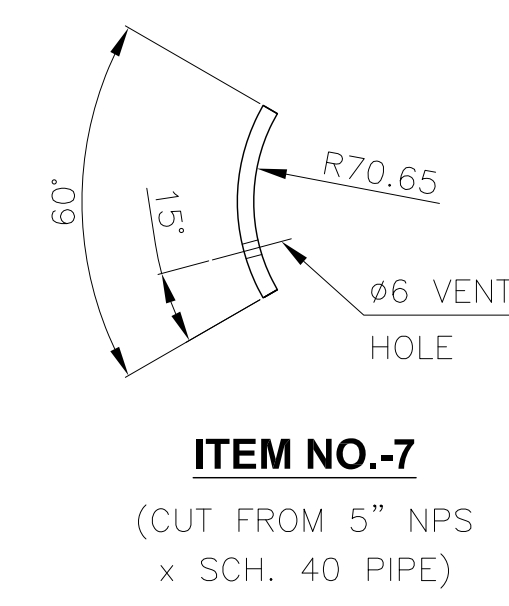
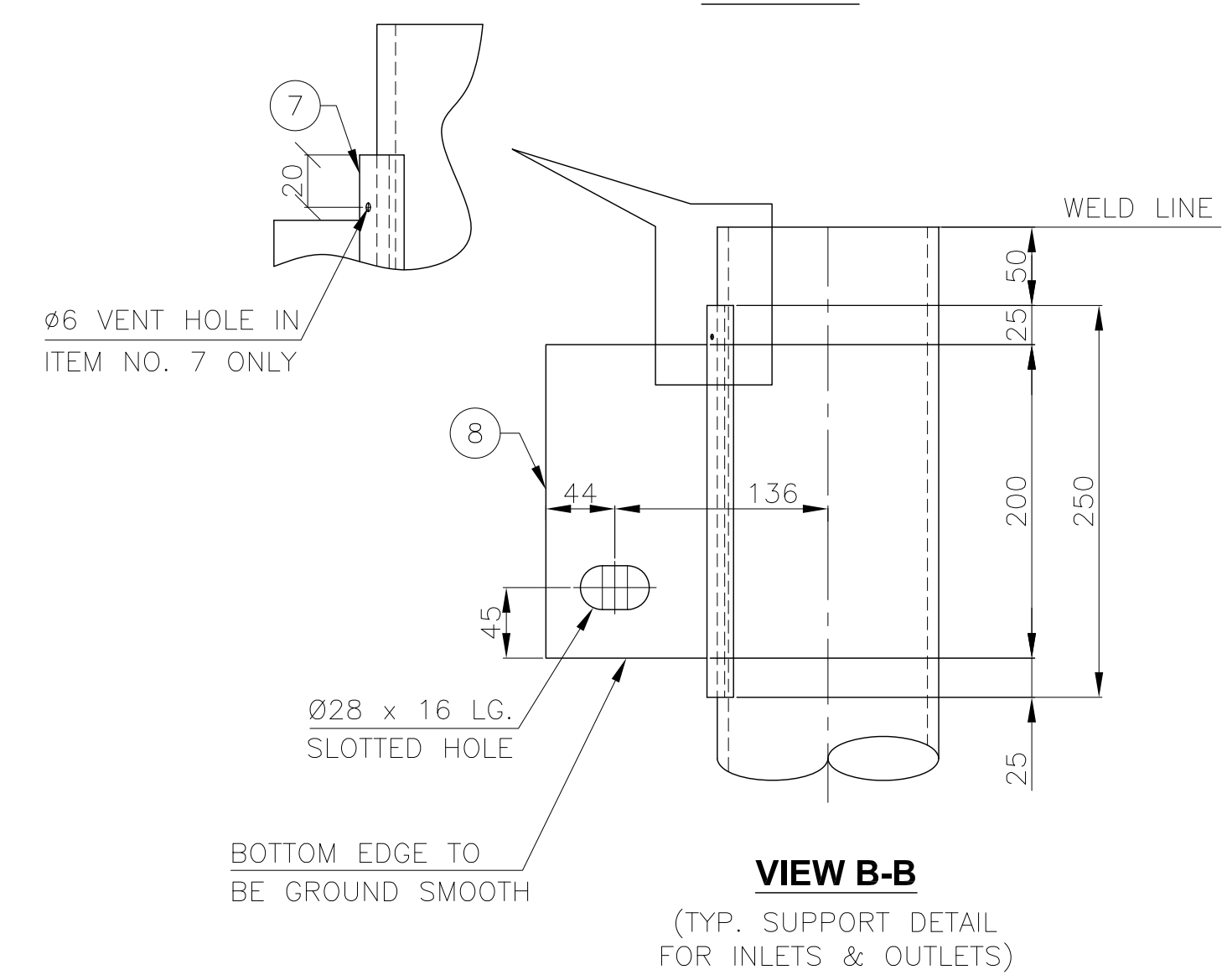
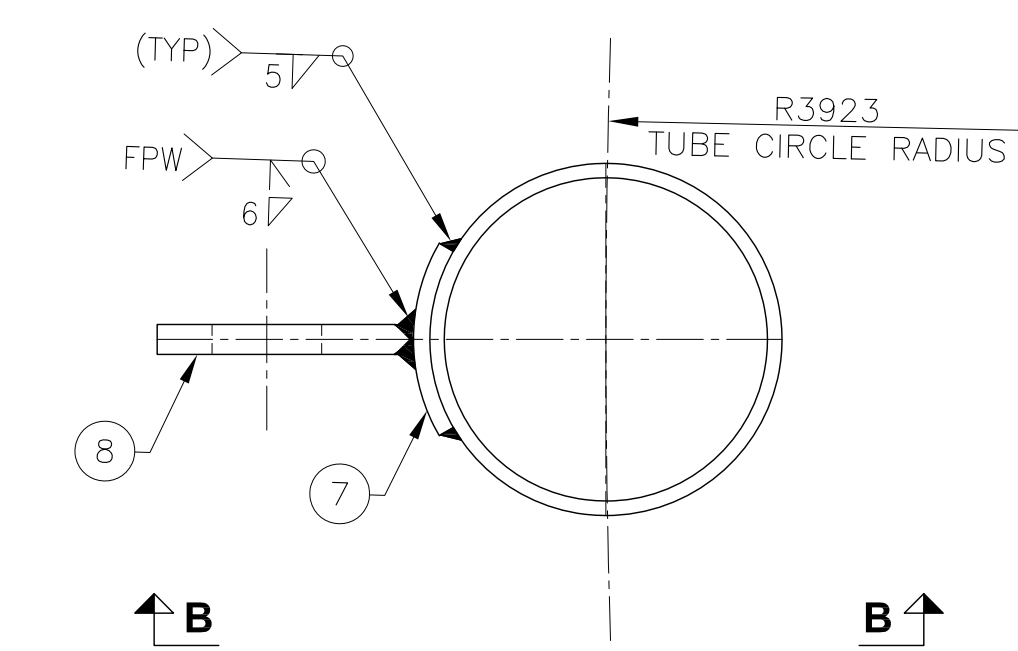
		2		1					
BILL OF MATERIAL									
MK. NO.	ITEM NO.	QTY	DESCRIPTION	SIZE		LENGTH (MM)	MATERIAL	UNIT WT(KG/M)	WT. (in KG.)
				WIDTH	THK.				
MK.116-RC-1 & 3	1	20	PIPE	5" NPS x SCH.40	BBE	15545	A335 Gr.P9	21.7	6759.0
	1A	2	PIPE	5" NPS x SCH.40	BBE	15570	A335 Gr.P9	21.7	677.0
	2	2	PIPE	5" NPS x SCH.40	BBE	563.5	A335 Gr.P9	21.7	24.5
	3	20	RETURN BEND	5" NPS x SCH.40 x 180°	SR		A234 Gr.WP9	8.6	172.0
	4	2	ELBOW	5" NPS x SCH.40 x 90°	LR		A234 Gr.WP9	6.5	12.9
	5	10	PIPE	1 1/2" NPS x SCH.80	BBE	771	A312 TP310	5.4	41.6
	6	10	SOCKOLET	5" x 1 1/2" NPS x 3000#			A182 Gr. F9	0.7	7.0
	7	2	PIPE	5" NPS x SCH.40	BBE	250	A335 Gr.P9	21.7	10.9
	8	2	PLATE	103	12	200	SS 310	—	3.9
WEIGHT									7709
MK.116-RC-1A & 3A	1	20	PIPE	5" NPS x SCH.40	BBE	15545	A335 Gr.P9	21.7	6759.0
	1A	2	PIPE	5" NPS x SCH.40	BBE	15570	A335 Gr.P9	21.7	677.0
	3	12	RETURN BEND	5" NPS x SCH.40 x 180°	SR		A234 Gr.WP9	8.6	103.2
	4	2	ELBOW	5" NPS x SCH.40 x 90°	LR		A234 Gr.WP9	6.5	12.9
	5	6	PIPE	1 1/2" NPS x SCH.80	BBE	771	A312 TP310	5.4	25.0
	6	10	SOCKOLET	5" x 1 1/2" NPS x 3000#			A182 Gr. F9	0.7	7.0
	7	2	PIPE	5" NPS x SCH.40	BBE	250	A335 Gr.P9	21.7	10.9
	8	2	PLATE	103	12	200	SS 310	—	3.9
	9	8	RETURN BEND	5" NPS x SCH.40 x 180°	LR		A234 Gr.WP9	12.9	103.2
	10	4	PIPE	1 1/2" NPS x SCH.80	BBE	708	A312 TP310	5.4	15.3
	11	2	PIPE	5" NPS x SCH.40	BBE	643	A335 Gr.P9	21.7	28.0
	12	2	FLANGE	5" NPS x SCH.40 x 300#	RFWN		A182 Gr.F9	14.6	29.2
	13	2	WELDOLET	5" NPS SCH.40 x 1 1/2" NPS SCH.80			A182 Gr.F9	0.8	1.6
	14	2	FLANGE	1 1/2" NPS x SCH.80 x 300#	RFWN		A182 Gr.F9	3.2	6.4
	15	2	BLIND FLANGE	1 1/2" NPS x 300#			A182 Gr.F9	2.7	5.4
	16	8	STUDS	M20 FULL THRD.		95	A 193 Gr.B7		—
	17	16	NUT	M20 HEAVY HEX.		STD	A 194 Gr.2H		—
	18	2	GASKET	1 1/2" NPS x 300#			SS 316L MATERIAL FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER		
WEIGHT									7788

1	11.10.22	WHOLE DRAWING REVISED & IFA	AJ	NA	NA	ALI	AD
0	26.08.22	ISSUED FOR APPROVAL	SA	MK	NA	ALI	AD
REV.	DATE	DESCRIPTION	DWN.	CHK.	APPD.	MECH. ENGR.	PROJ. MGR.
THIS DRAWING AND THE DESIGN IT COVERS ARE THE PROPERTY OF AG FURNACE IMPROVEMENTS. THEY ARE MERELY LOANED AND ON THE BORROWER'S EXPRESS AGREEMENT THAT THEY WILL NOT BE COPIED, LOANED, EXHIBITED NOR USED EXCEPT IN THE LIMITED WAY AND PRIVATE USE PERMITTED BY ANY WRITTEN CONSENT GIVEN BY THE LENDER TO THE BORROWER.							
AGIS							
AG FURNACE IMPROVEMENTS PVT. LTD							
NOIDA, INDIA							
CLIENT: BHARAT HEAVY ELECTRICALS LTD.							
HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012							
TITLE : FRESH FEED FURNACE (412-H-1001)							
DETAILS OF RADIANT COILS							
SCALE :		DRG.No.		SHT. 2 OF 3		REV.	
1 : 24		AGFIS-116-DW-1004				1	

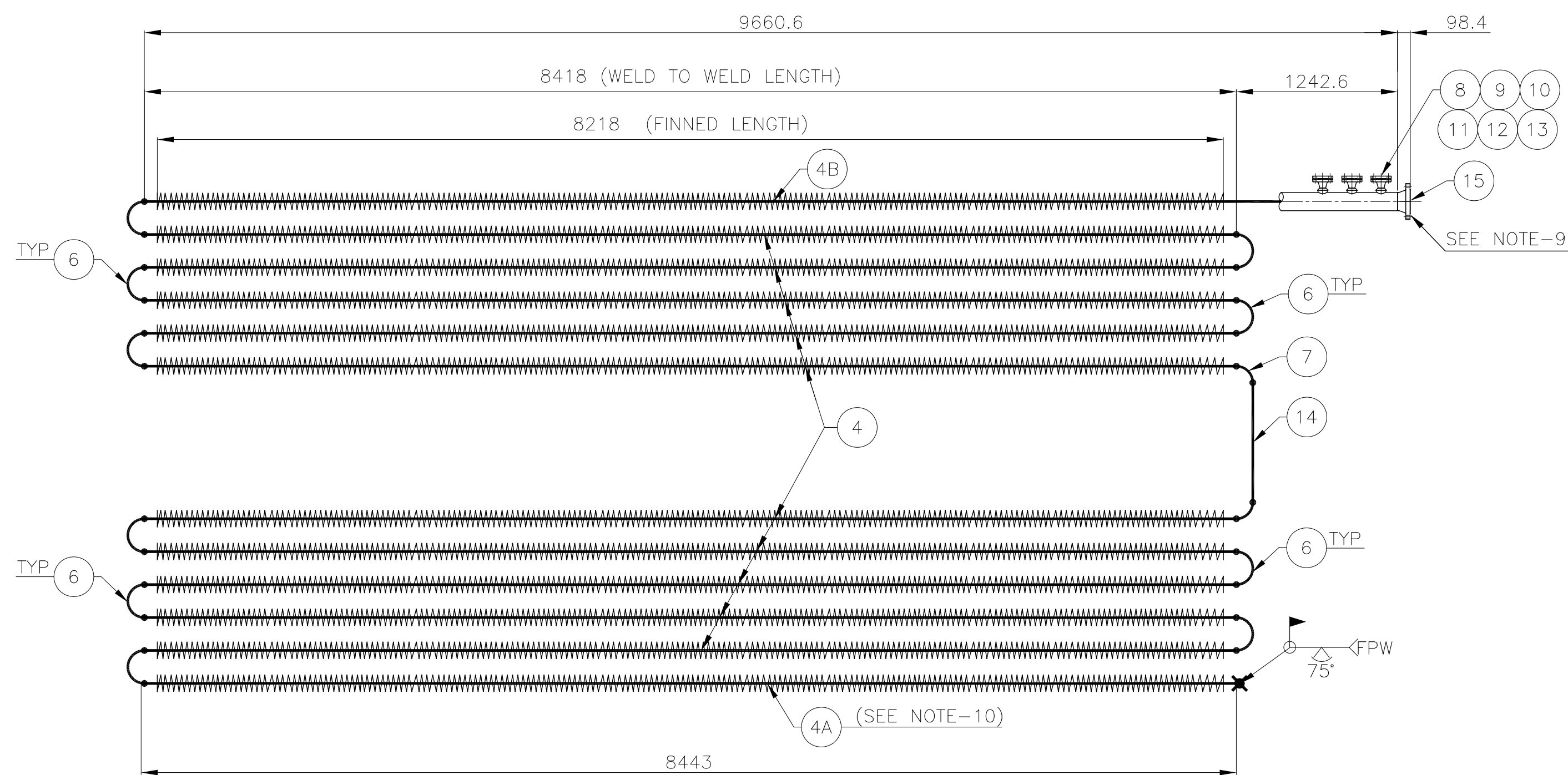
ALL DIMENSIONS ARE IN MILLIMETERS IN INCHES UNLESS NOTED OTHERWISE		THIRD ANGLE PROJECTION	
CLIENT : BHARAT HEAVY ELECTRICALS LTD.		LOCATION : IOCL, PANIPAT, INDIA	
UNIT : INDMAX FCCU		SERVICE : FRESH FEED FURNACE	
ITEM NO. : 412-H-1001		AGFIS JOB NO. : 116	



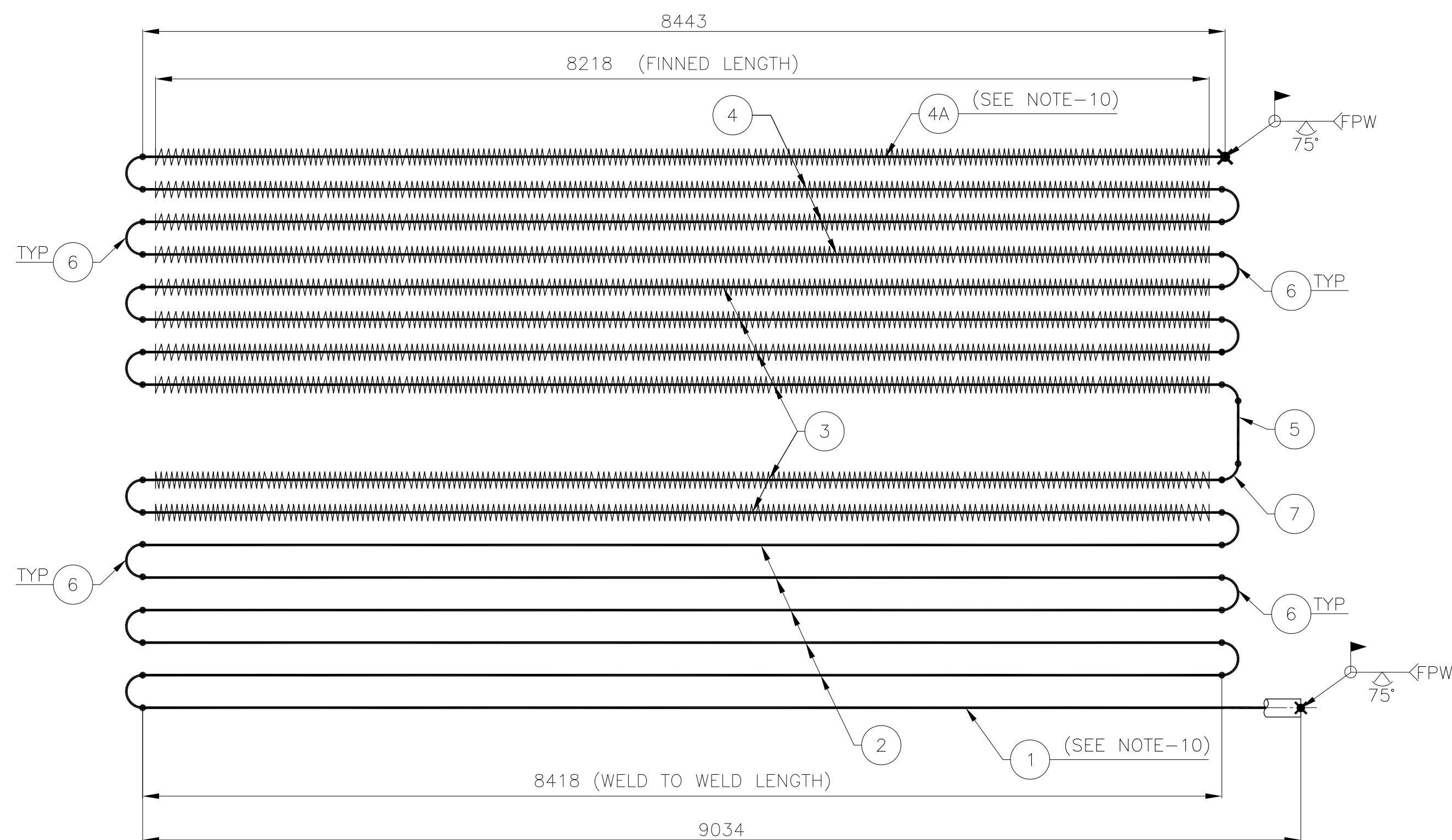
BILL OF MATERIAL						
ITEM NO.	M NO.	QTY	DESCRIPTION	SIZE		LENGTH (MM)
				WIDTH	THK.	
4	4	4	ELBOW	5" NPS x SCH.40 x 90' LR	A234 Gr.WP9	6.5
12	8	8	FLANGE	5" NPS x SCH.40 x 300# RFWN	A182 Gr.F9	14.6
14	4	4	FLANGE	1 1/2" NPS x SCH.80 x 300# RFWN	A182 Gr.F9	3.6
15	4	4	BLIND FLANGE	1 1/2" NPS x 300#	A182 Gr.F9	2.7
16	16	16	STUDS	M20 FULL THRD.	A 193 Gr.B7	95
17	32	32	NUT	M20 HEAVY HEX.	A 194 Gr.2H	STD
18	4	4	GASKET	1 1/2" NPS x 300#	SS 316L MATERIAL FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER	
19	4	4	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	311
20	4	4	ELBOLET	5" x 1 1/2" NPS x 3000#	A182 Gr. F9	0.7
WEIGHT						198
21	32	32	STUDS	M20 FULL THRD.	A 193 Gr.B7	125
22	64	64	NUT	M20 HEAVY HEX.	A 194 Gr.2H	STD
23	4	4	GASKET	1 1/2" NPS x 300#	SS 316L MATERIAL FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER	
TOTAL WEIGHT						31246



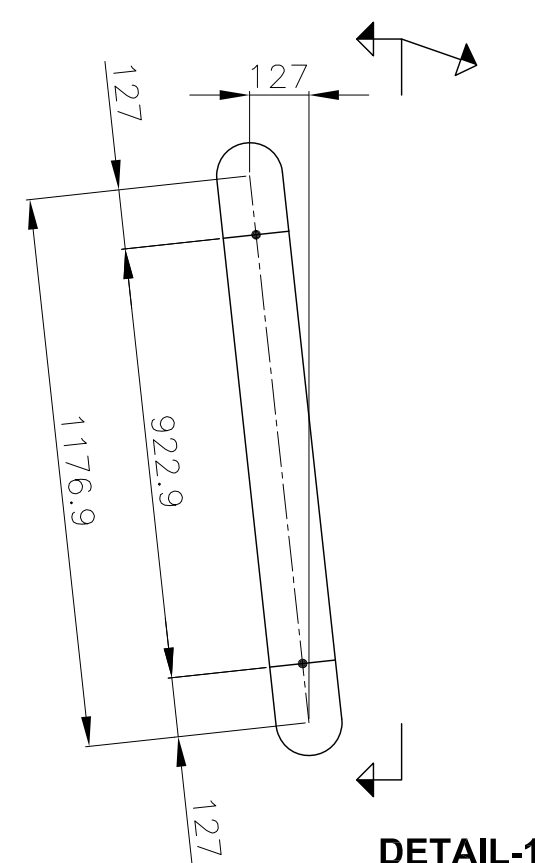
BILL OF MATERIAL									
ITEM NO.	M NO.	QTY	DESCRIPTION	SIZE		LENGTH (MM)			
				WIDTH	THK.				
1	20	20	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	15545			
1A	2	2	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	15570			
2	2	2	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	563.5			
3	20	20	RETURN BEND	5" NPS x SCH.40 x 180' SR	A234 Gr.WP9	8.6			
4	2	2	ELBOW	5" NPS x SCH.40 x 90' LR	A234 Gr.WP9	6.5			
5	10	10	PIPE	1 1/2" NPS x SCH.80 BBE	A312 TP310	771			
6	10	10	SOCKOLET	5" x 1 1/2" NPS x 3000#	A182 Gr. F9	0.7			
7	2	2	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	250			
8	2	2	PLATE	103	12	200			
WEIGHT						7709			
1	20	20	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	15545			
1A	2	2	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	15570			
3	12	12	RETURN BEND	5" NPS x SCH.40 x 180' SR	A234 Gr.WP9	8.6			
4	2	2	ELBOW	5" NPS x SCH.40 x 90' LR	A234 Gr.WP9	6.5			
5	6	6	PIPE	1 1/2" NPS x SCH.80 BBE	A312 TP310	771			
6	10	10	SOCKOLET	5" x 1 1/2" NPS x 3000#	A182 Gr. F9	0.7			
7	2	2	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	250			
8	2	2	PLATE	103	12	200			
9	8	8	RETURN BEND	5" NPS x SCH.40 x 180' LR	A234 Gr.WP9	12.9			
10	4	4	PIPE	1 1/2" NPS x SCH.80 BBE	A312 TP310	708			
11	2	2	PIPE	5" NPS x SCH.40 BBE	A335 Gr.P9	643			
12	2	2	FLANGE	5" NPS x SCH.40 x 300# RFWN	A182 Gr.F9	14.6			
13	2	2	WELDOLET	5" NPS SCH.40 x 1 1/2" NPS SCH.80	A182 Gr.F9	0.8			
14	2	2	FLANGE	1 1/2" NPS x SCH.80 x 300# RFWN	A182 Gr.F9	3.2			
15	2	2	BLIND FLANGE	1 1/2" NPS x 300#	A182 Gr.F9	2.7			
16	8	8	STUDS	M20 FULL THRD.	A 193 Gr.B7	95			
17	16	16	NUT	M20 HEAVY HEX.	A 194 Gr.2H	STD			
18	2	2	GASKET	1 1/2" NPS x 300#	SS 316L MATERIAL FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER				
WEIGHT						7788			
3	4	4	RETURN BEND	5" NPS x SCH.40 x 180' SR	A234 Gr.WP9	8.6			
5	4	4	PIPE	1 1/2" NPS x SCH.80 BBE	A312 TP310	771			
6	4	4	SOCKOLET	5" x 1 1/2" NPS x 3000#	A182 Gr. F9	0.7			
WEIGHT						54			
1	11.10.22	WHOLE DRAWING REVISED & IFA			AJ	NA			
0	26.08.22	ISSUED FOR APPROVAL			SA	MK			
REV.	DATE	DESCRIPTION			DWN.	CHK.			
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AG FURNACE IMPROVEMENTS PVT. LTD Noida, India									
CLIENT: BHARAT HEAVY ELECTRICALS LTD. HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012									
TITLE: FRESH FEED FURNACE (412-H-1001)									
DETAILS OF RADIANT COILS									
SCALE: 1:24	DRG.No. AGFIS-116-DW-1004			SHT. 3 OF 3		REV. 1			



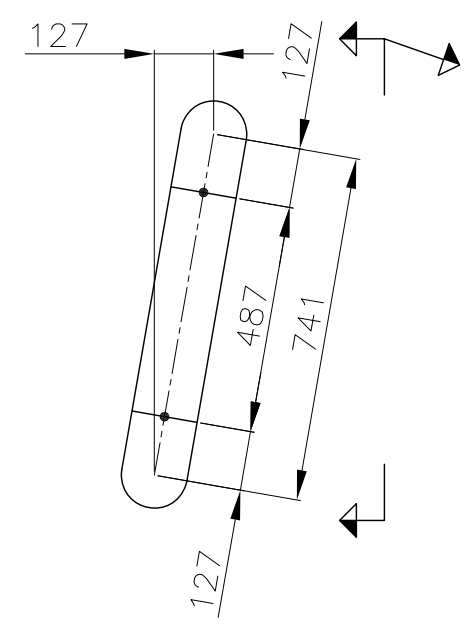
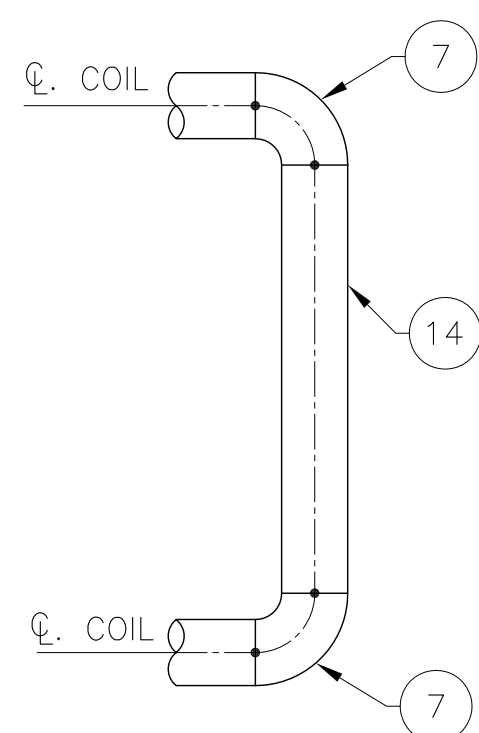
CONVECTION COIL DEVELOPED VIEW FOR PASS #1 TO #4
MK.-116-CC-2



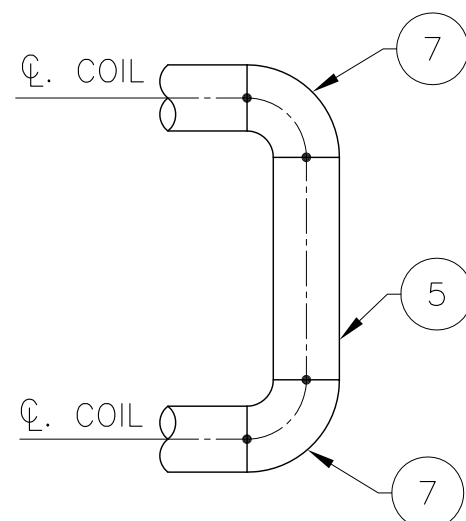
CONVECTION COIL DEVELOPED VIEW FOR PASS #1 TO #4
MK.-116-CC-1



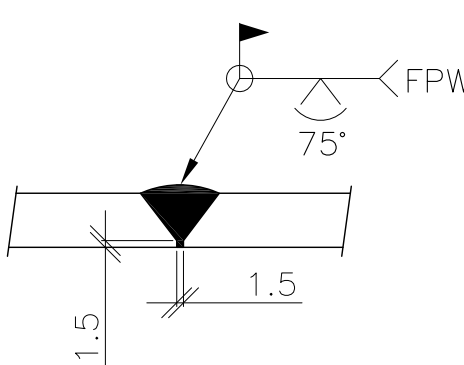
DETAIL-1



DETAIL-2

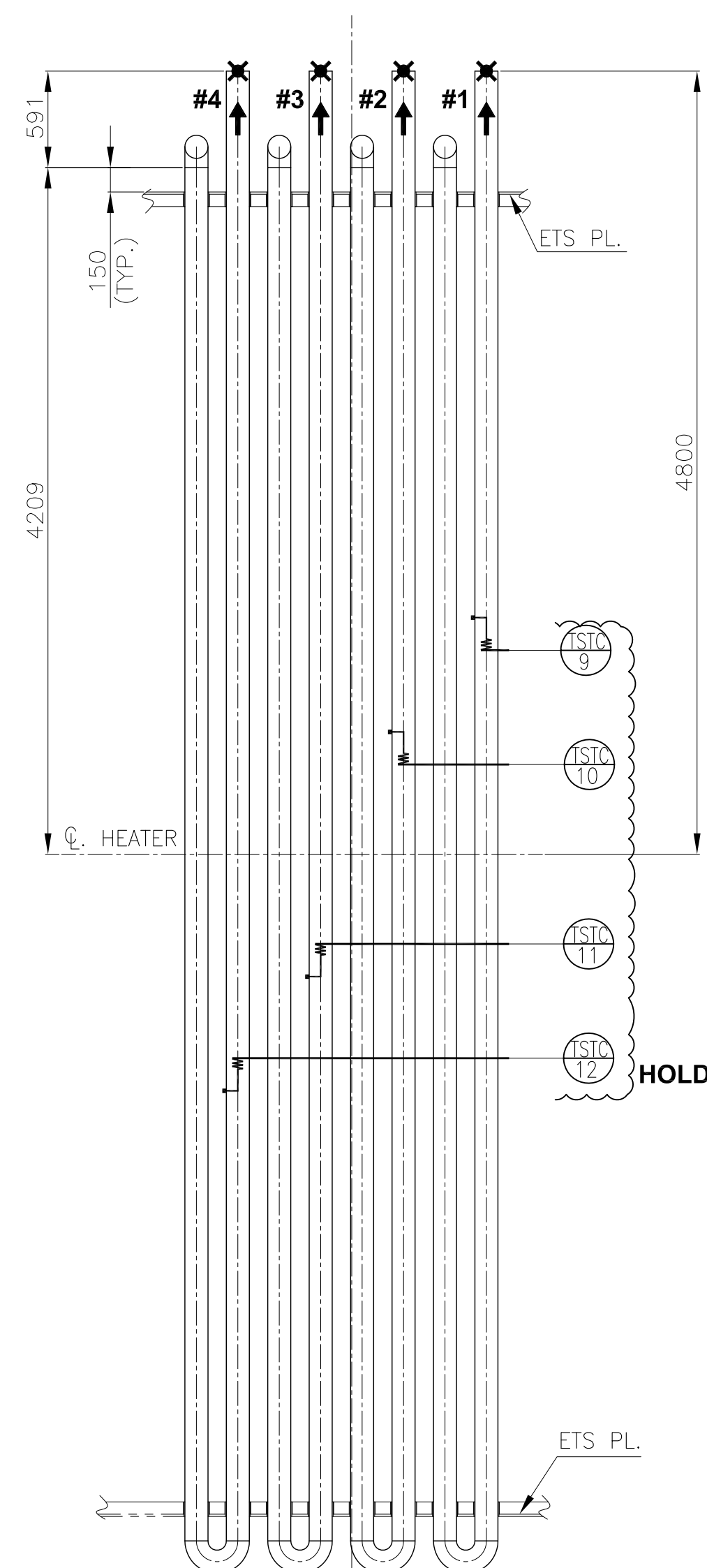


TYPICAL FIELD BUTT WELD DETAIL



BILL OF MATERIAL									
MK. NO.	ITEM NO.	QTY	DESCRIPTION	SIZE		LENGTH (MM)	MATERIAL	UNT WT (KG/M)	WT. (in KG.)
				WIDTH	THK.				
	MK. 116-CC-SP-1								
	15	8	FLANGE	5" NPS x SCH.40 x 300#		WNRF	A182 Gr.F9	14.6	116.8
	16	4	PIPE	5" NPS x SCH.40		BBE	A335 Gr.P9	21.7	35.
	WEIGHT								152
	MK. 116-CC-JO-1								
	7	8	ELBOW	5" NPS x SCH.40 x 90°		SR	A234 Gr. WP9	4.3	34.4
	17	4	PIPE	5" NPS x SCH.40		BBE	A335 Gr.P9	21.7	14.4
	WEIGHT								45
	TOTAL WEIGHT								4185
	FIELD MATERIAL								
	18	4	GASKET	5" NPS x 300#			SS 316L FOR INNER, OUTER RING & WINDING STRIP, COIL SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER		
	19	32	STUDS	M20	FULL THRD.		125	A 193 Gr.B7	—
	20	64	NUT	M20	HEAVY HEX.		STD	A 194 Gr.2H	—

18	4	GASKET	5" NPS x 300#		SS 316L FOR INNER, OUTER RING & WINDING STRIP, CGL SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER
19	32	STUDS	M20 FULL THRD.	125	A 193 Gr.2 — —
20	64	NUT	M20 HEAVY HEX.	STD	A 194 Gr.2H — —



SECTION A-A
(CONVECTION OUTLET PLAN VIEW)

BILL OF MATERIAL									
MK. NO.	ITEM NO.	QTY	DESCRIPTION	SIZE		LENGTH (MM)	MATERIAL	UNT. WT (KG/M)	WT. (in KG.)
				WIDTH	THK.				
MK. 116-CC-1	1	4	PIPE	5" NPS x SCH.40	BBE	9034	A335 Gr.P9	21.7	785.6
	2	20	PIPE	5" NPS x SCH.40	BBE	8418	A335 Gr.P9	21.7	3660.1
	3	24	PIPE	5" NPS x SCH.40	BBE	8418	A335 Gr.P9	21.7	4392.2
			SOLID FIN	1.52 THK. x 12.7 HT x 197 FINS/M	8218	11-13Cr	15.3	3021.6	
	4	12	PIPE	5" NPS x SCH.40	BBE	8418	A335 Gr.P9	21.7	2196.1
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	3178.4	
	4A	4	PIPE	5" NPS x SCH.40	BBE	8443	A335 Gr.P9	21.7	734.2
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	1059.5	
	5	4	PIPE	5" NPS x SCH.40	BBE	487	A335 Gr.P9	21.7	42.3
	6	56	RETURN BEND	5" NPS x SCH.40 x 180°	SR	A234 Gr.WP9	8.6	481.6	
7	8	ELBOW	5" NPS x SCH.40 x 90°	SR	A234 Gr.WP9	4.3	34.4		
WEIGHT									19586
MK. 116-CC-2	4	40	PIPE	5" NPS x SCH.40	BBE	8418	A335 Gr.P9	21.7	7320.3
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	10594.6	
	4A	4	PIPE	5" NPS x SCH.40	BBE	8443	A335 Gr.P9	21.7	734.2
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	1059.5	
	4B	4	PIPE	5" NPS x SCH.40	BBE	9660.6	A335 Gr.P9	21.7	840.1
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	1059.5	
	6	40	RETURN BEND	5" NPS x SCH.40 x 180°	SR	A234 Gr.WP9	8.6	344.0	
	7	8	ELBOW	5" NPS x SCH.40 x 90°	SR	A234 Gr.WP9	4.3	34.4	
	8	12	WELDOLET	5" NPS x SCH.40 x 1 1/2" NPS x SCH.80		A182 Gr.F9	1.0	12.0	
	9	12	FLANGE	1 1/2" NPS x SCH.80 x 300# WNRF		A182 Gr.F9	3.2	38.4	
	10	12	BLIND FLANGE	1 1/2" NPS x 300# RF		A182 Gr.F9	2.7	32.4	
	11	12	GASKET	1 1/2" NPS x 300#			SS 316L FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER		
	12	48	STUD	M20 FULL THREADED.		95	A 193 Gr.B7	—	—
	13	96	NUT	M20 HEAVY HEX.		STD	A 194 Gr.2H	—	—
	14	4	PIPE	5" NPS x SCH.40	BBE	922.9	A335 Gr.P9	21.7	80.3
15	4	FLANGE	5" NPS x SCH.40 x 300#	WNRF	A182 Gr.F9	14.6	58.4		
WEIGHT									22069

MK. 116-CC-2	4	40	PIPE	5" NPS x SCH.40 BBE	8418	A335 Gr.P9	21.7	7320.3
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	10594.6
	4A	4	PIPE	5" NPS x SCH.40 BBE	8443	A335 Gr.P9	21.7	7342
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	1059.5
	4B	4	PIPE	5" NPS x SCH.40 BBE	9660.6	A335 Gr.P9	21.7	840.1
			SOLID FIN	1.52 THK. x 25.4 HT x 197 FINS/M	8218	CS	32.2	1059.5
	6	40	RETURN BEND	5" NPS x SCH.40 x 180° SR	A234 Gr.WP9	8.6	344.0	
	7	8	ELBOW	5" NPS x SCH.40 x 90° SR	A234 Gr.WP9	4.3	34.4	
	8	12	WELDOLET	5" NPS x SCH.40 x 1 1/2" NPS x SCH.80	A182 Gr.F9	1.0	12.0	
	9	12	FLANGE	1 1/2" NPS x SCH.80 x 300# WNRF	A182 Gr.F9	3.2	38.4	
	10	12	BLIND FLANGE	1 1/2" NPS x 300# RF	A182 Gr.F9	2.7	32.4	
	11	12	GASKET	1 1/2" NPS x 300#	SS 316L FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER			
	12	48	STUD	M20 FULL THREADED.	95	A 193 Gr.B7	—	—
	13	96	NUT	M20 HEAVY HEX.	STD	A 194 Gr.2H	—	—
	14	4	PIPE	5" NPS x SCH.40 BBE	922.9	A335 Gr.P9	21.7	80.3
15	4	FLANGE	5" NPS x SCH.40 x 300# WNRF	A182 Gr.F9	14.6	58.4		
WEIGHT							22069	

1	11.10.22	WHOLE DRAWING REVISED & IFA	MS	MK	NA	ALI	AD
0	26.08.22	ISSUED FOR APPROVAL	SS	MK	NA	ALI	AD
REV.	DATE	DESCRIPTION	DWN.	CHK.	APPD.	MECH. ENGR.	PROJ. MGR.

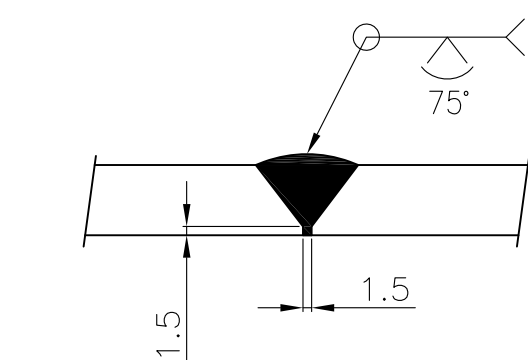
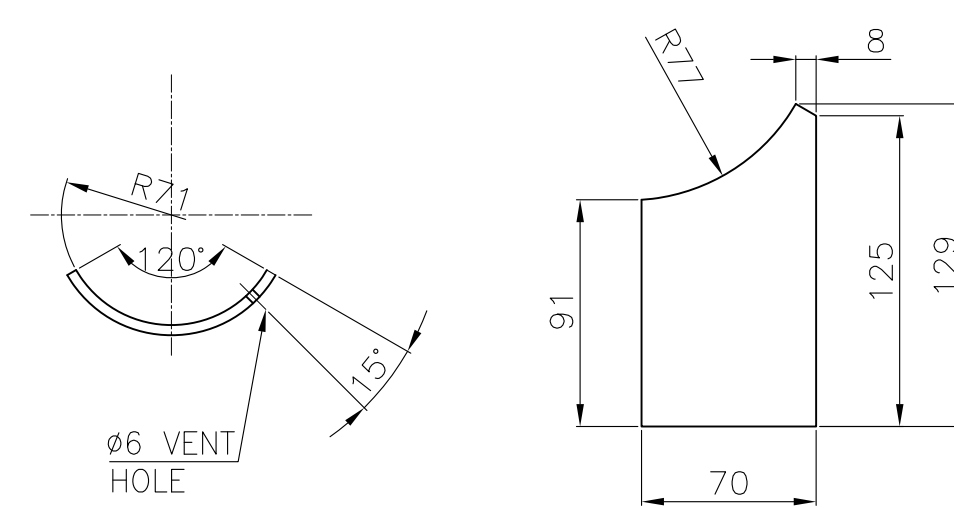
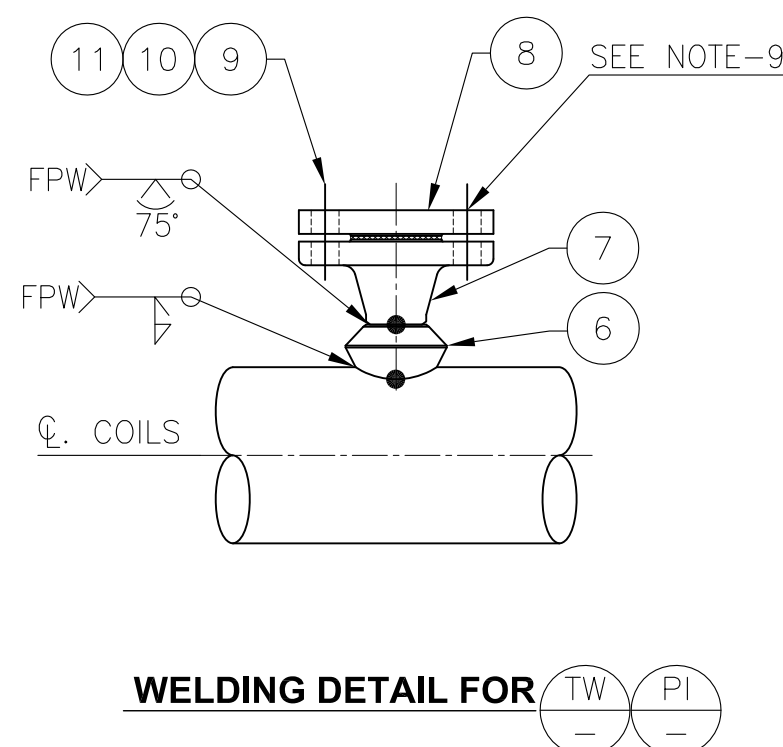
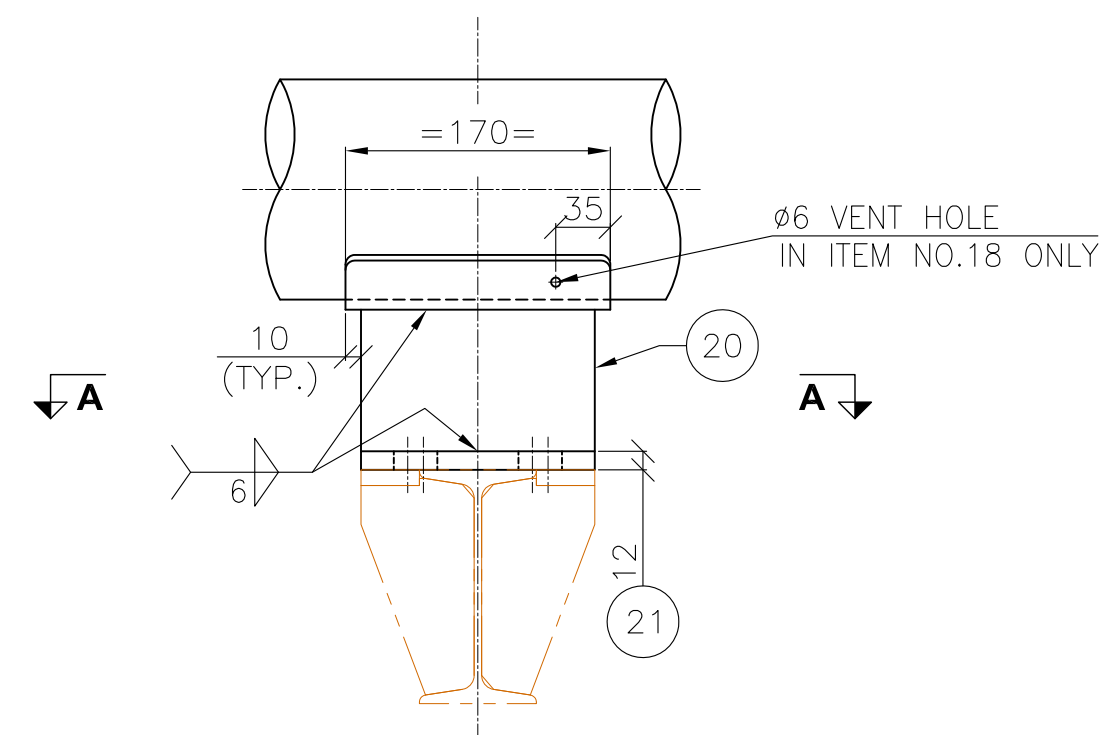
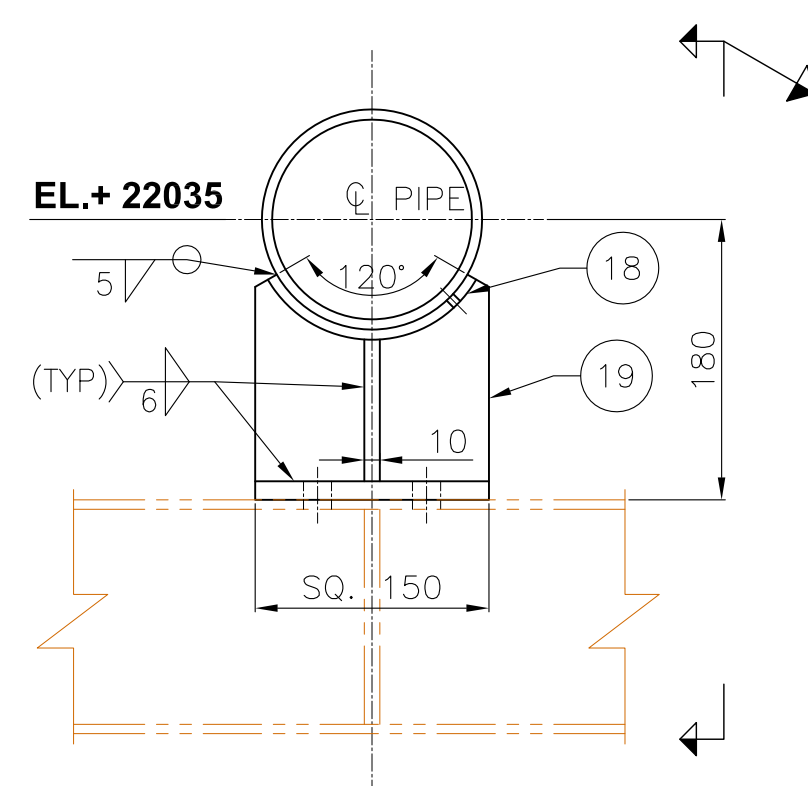
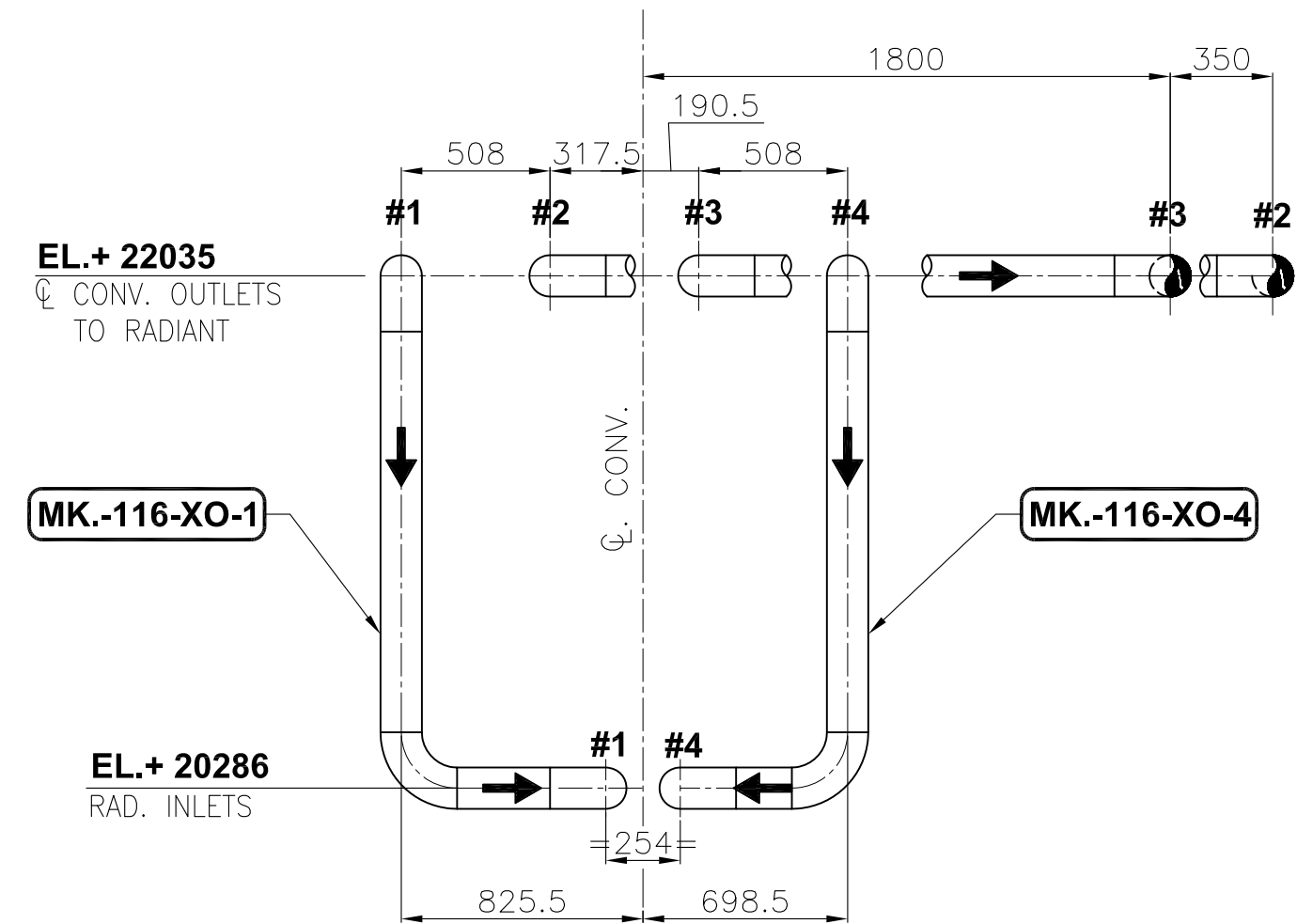
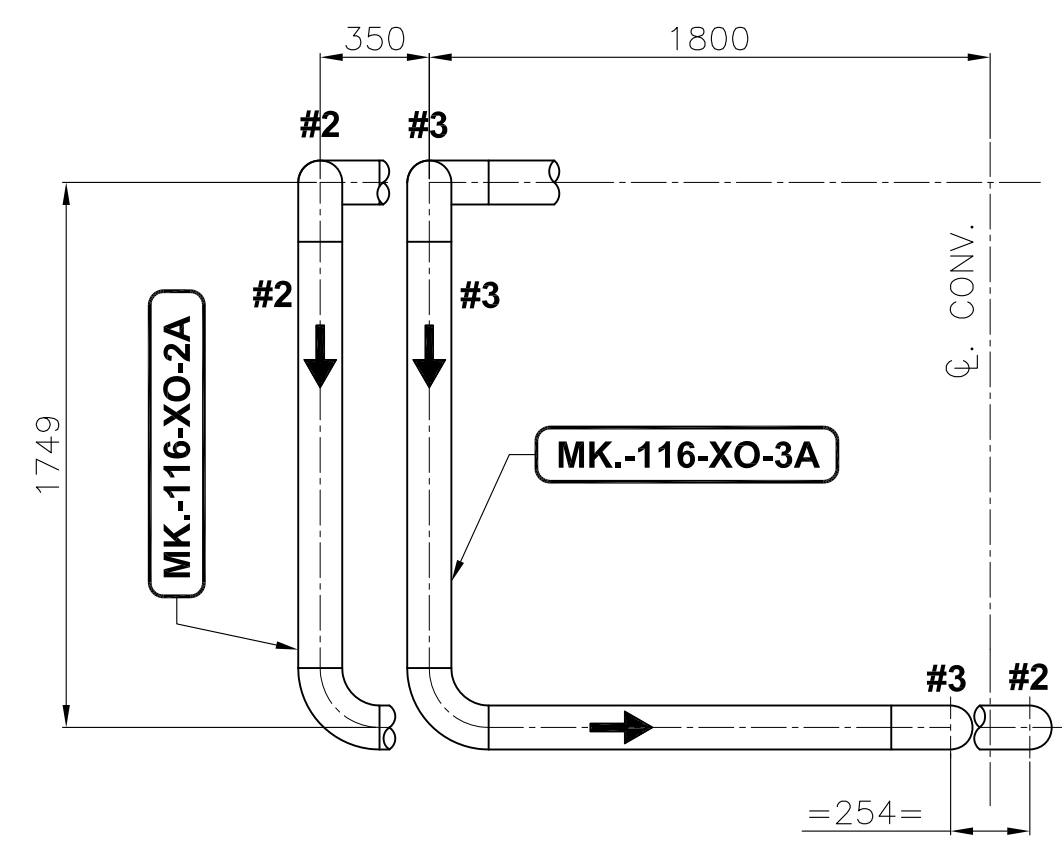
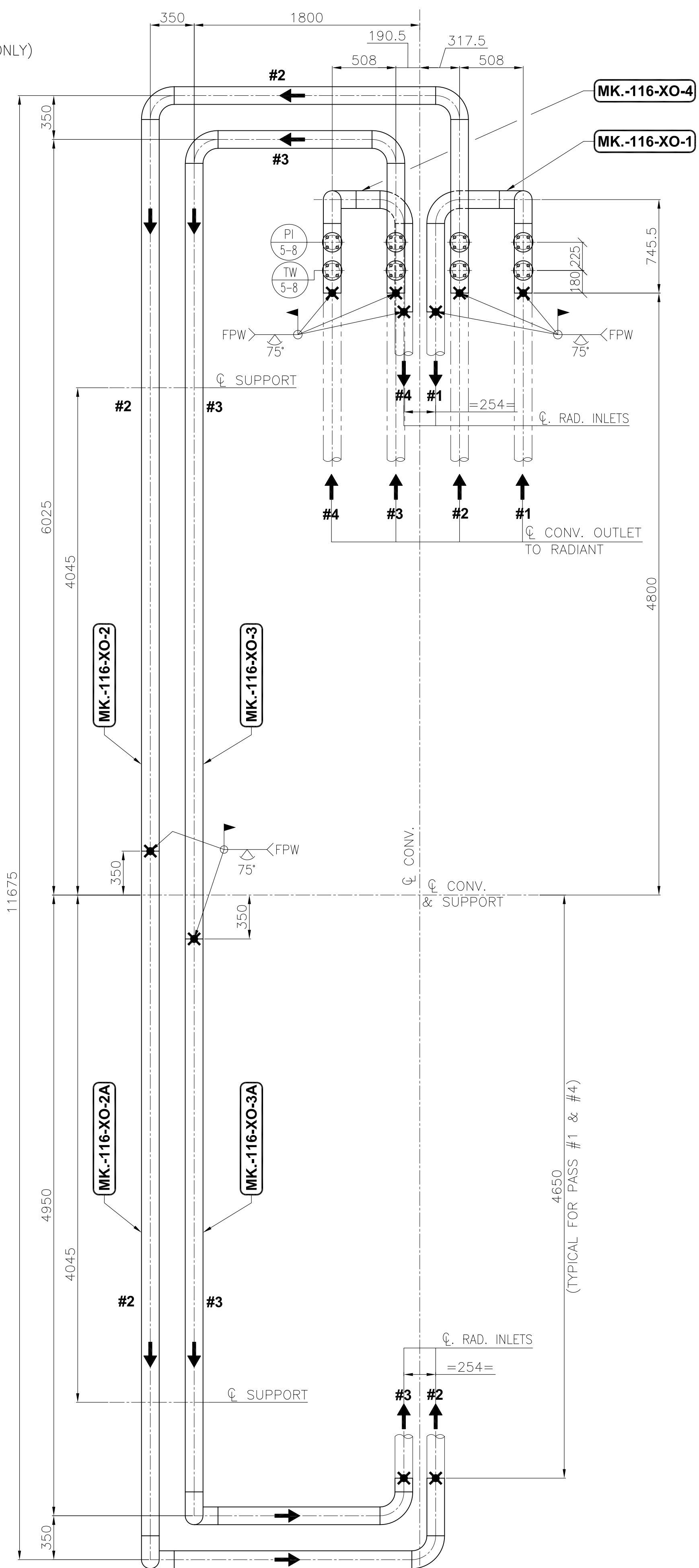
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AG FURNACE IMPROVEMENTS PVT. LTD.
 NOIDA, INDIA

CLIENT:  **BHARAT HEAVY ELECTRICALS LTD.**
HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012

D.	TITLE :	<u>FRESH FEED FURNACE (412-H-1001)</u>
	DETAILS OF CONVECTION COILS	

SCALE :	DRG.No.	REV.
1 : 32	AGFIS-116-DW-1005	SHT. 2 OF 2 1



REFERENCE DRAWINGS	
DRAWING NO.	TITLE
AGFIS-116-DW-1001	GA— ELEVATION AND PLANS OF HEATER
AGFIS-116-DW-1004	DETAILS OF RADIANT COILS
AGFIS-116-DW-1005	DETAILS OF CONVECTION COILS

NOTES :-

1. DO NOT SCALE THE DRAWING, ASK IF IN DOUBT.
2. ALL DIMENSIONS AND UNITS ARE IN THE MKS SYSTEM, U.N.O.
3. ELEVATIONS GIVEN ARE RELEVANT TO REF. GRADE EL+0000.
4. ALL ITEMS SHALL BE CHECKED BY FULL SCALE LAYOUT BEFORE FABRICATION.
5. NO UNDER CUT OF PIPE WALL IS PERMITTED DUE TO WELDING
6. COMPLETED ASSEMBLIES TO BE SHOP HYDRO TESTED AFTER COMPLETION OF WELDING AND ALL STATED INSPECTION REQUIREMENTS.
7. COIL SHALL BE DRIED AFTER HYDROTEST.
8. ALL WELD PREPARATION SHALL CONFORM TO ANSI B16.25 AND PROJECT SPEC.
9. ALL FLANGE BOLT HOLES SHALL STRADDLE NATURAL CENTER LINES.
10. PIPES WITH FIELD WELDS SHALL HAVE 25mm EXTRA LENGTH TO PERMIT WELDING OF CAP/BLIND FOR HYDRO TEST. THE EXTRA LENGTH SHALL BE TRIMMED AFTER HYDRO-TEST AND PROVIDED WITH WELD BEVELS.
11. ALL COIL WELDS MUST BE FULL PENETRATION TYPE.
12. ALL PIPES AND FITTINGS SHALL BE SEAMLESS TYPE.
13. FIELD WELDING ENDS OF ALL ELBOWS, WELDOLETS SHALL BE COVERED SUITABLY BY COIL FABRICATOR TO PROTECT ENDS DURING TRANSPORTATION AND HANDLING.
14. PWHT SHALL BE CARRIED OUT ON PRESSURE PART WELD AS PER PROJECT SPEC.
15. 100% RT REQUIRED FOR ALL WELDS AFTER PWHT.
16. 100% PMI TESTING REQUIRED ON ALLOY PRESSURE PART WELDS INCLUDING WELD FILLER MATERIALS.
17. GENERAL ENGINEERING SPECIFICATION FOR FIRED HEATER DOC. NO. 6745-PRC-000-EC-003.
18. EIL ENGINEERING DESIGN BASIS (PART-B) DOC. NO. B269-999-02-42-ODB-1001.
19. ENGINEERING DESIGN BASIS FIRED HEATER EQUIPMENT MECHANICAL DOC. NO. B269-999-80-44-EDB-1001.
20. TECHNICAL SPECIFICATION FOR PIPE, FITTING, FLANGES, GASKET & FASTENERS DOC. NO. 6745-PIP-EC-0001.
21. EIL STANDARD SPECIFICATION OF COIL WORK FOR FIRED HEATERS. DOC. NO. 6-17-0003.
22. SPECIFICATION FOR POSITIVE IDENTIFICATION (PMI) AT SUPPLIER'S WORK DOC. NO. 6745-PIP-EC-0006.
23. LEGEND:-

BBE	:	BEVELED ON BOTH ENDS
●	:	INDICATES SHOP WELD
✱	:	INDICATES FIELD WELD
FPW	:	FULL PENETRATION WELD
EL.	:	ELEVATION
Ⓢ	:	CENTER LINE

DESIGN CONDITIONS	
DESIGN CODE (TUBE)	ASME B31.3
DESIGN PRESSURE, ELASTIC/RUPTURE, (KG/CM ²)(G)	29.6
DESIGN FLUID TEMP. (°C)	324
SHOP HYDROTEST PRESSURE (KG/CM ²)	55
FIELD HYDROTEST PRESSURE (KG/CM ²)	55
CORROSION ALLOWANCE-COIL(MM)	3
RADIOGRAPHY: (ALL PRESSURE PART)	100%
POST WELD HEAT TREATMENT	YES

0	11.10.22	ISSUED FOR APPROVAL	SS	MK	NA	ALI	AD
REV.	DATE	DESCRIPTION	DWN.	CHK.	APPD	MECH. FNGR	PROJ. MGR

THIS DRAWING AND THE DESIGN IT COVERS ARE THE PROPERTY OF AG FURNACE IMPROVEMENTS. THEY ARE MERELY LOANED AND ON THE BORROWER'S EXPRESS AGREEMENT THAT THEY WILL NOT BE COPIED, LOANED, EXHIBITED NOR USED EXCEPT IN THE LIMITED WAY AND PRIVATE USE PERMITTED BY ANY WRITTEN CONSENT GIVEN BY THE LENDER TO THE BORROWER.

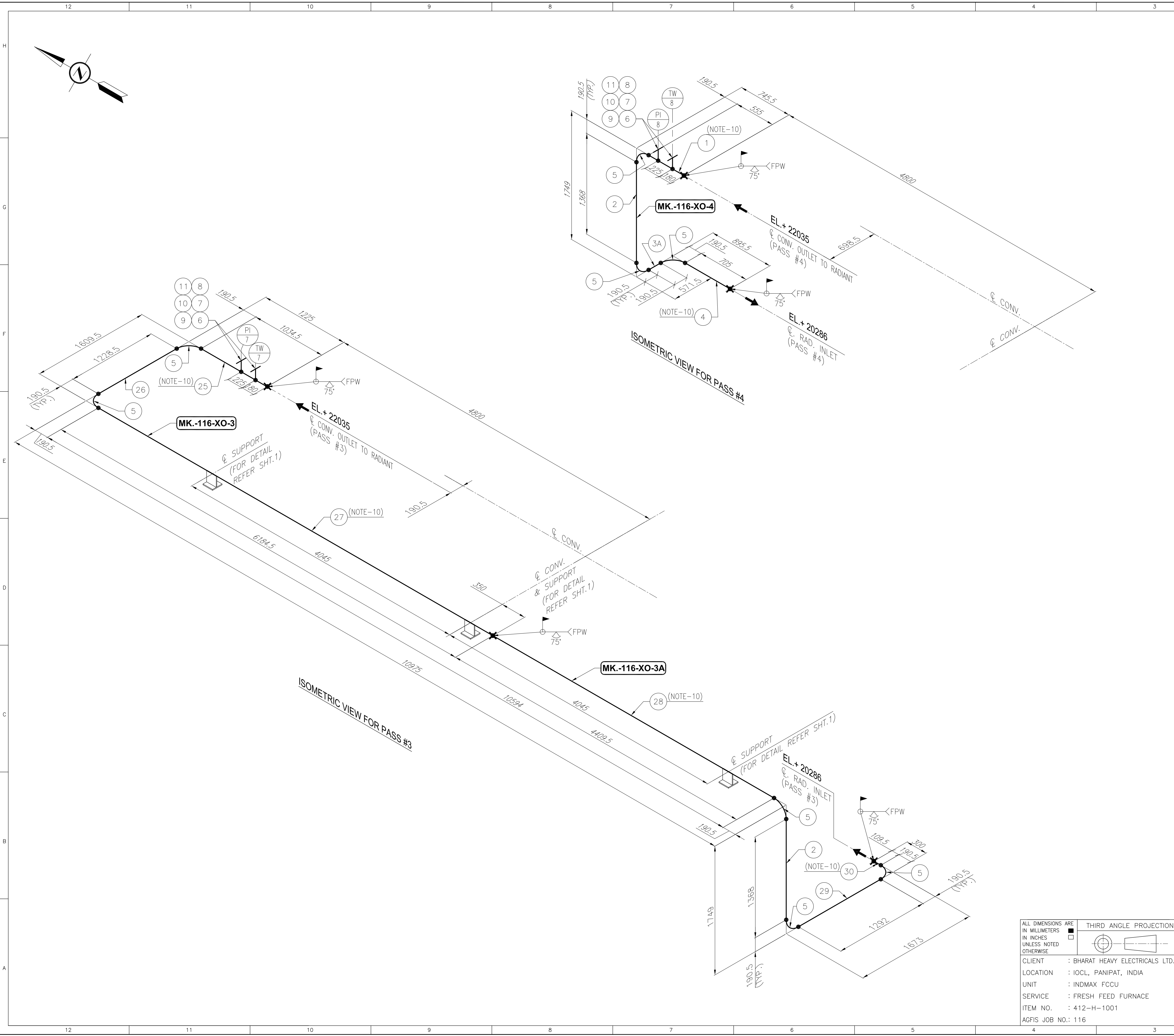

AG FURNACE IMPROVEMENTS PVT. LTD.
 NOIDA, INDIA

CLIENT:  **BHARAT HEAVY ELECTRICALS LTD.**
HEAVY PLATES & VESSELS PLANT UNIT, VISAKHAPATNAM-530012

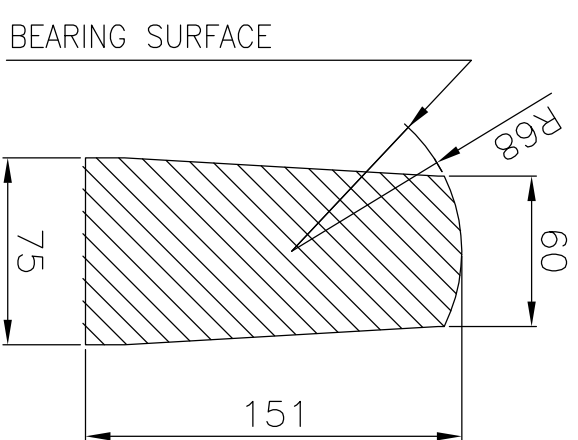
D. TITLE : FRESH FEED FURNACE (412-H-1001)

DETAILS OF CROSS-OVERS

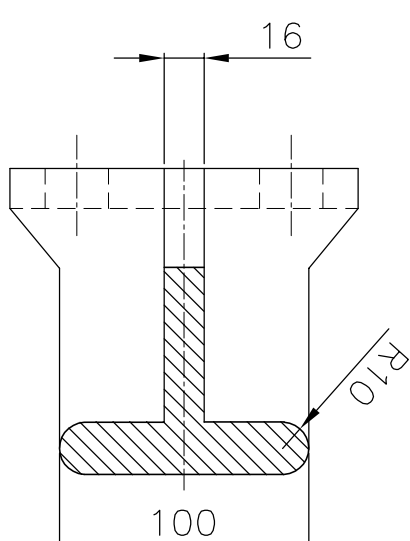
SCALE :	DRG.No.	REV.
1 : 24	AGFIS-116-DW-1006	SHT. 1 OF 3
		0



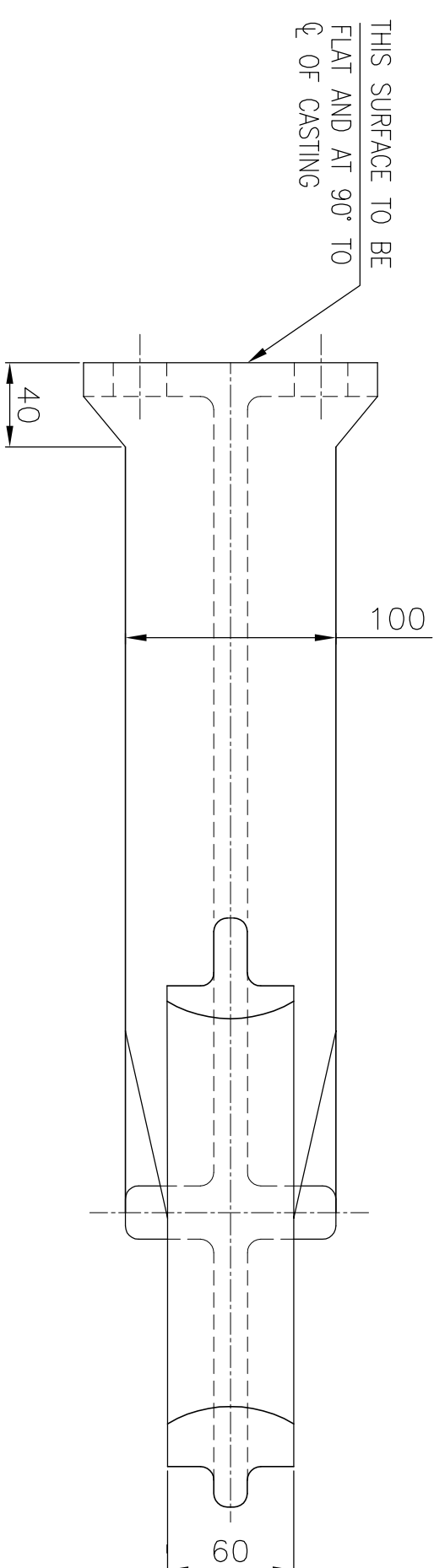
BILL OF MATERIAL										
MK. NO.	ITEM NO.	QTY	DESCRIPTION	SIZE		LENGTH (MM)	MATERIAL	UNT WT (KG/M)	WT. (in KG.)	
				WIDTH	THK.					
MK.-116-XO-3 & 3A	2	1	PIPE	5" NPS x SCH.40	BBE	1368	A335 Gr.P9	21.7	29.7	
	5	5	ELBOW	5" NPS x SCH.40 x 90°	LR		A234 Gr. WP9	6.5	32.3	
	6	2	WELDOLET	5" NPS x SCH.40 x 1 1/2" NPS x SCH.80			A182 Gr.F9	0.5	1.0	
	7	2	FLANGE	1 1/2" NPS x SCH.80 x 300#	RFWN		A182 Gr.F9	3.2	6.4	
	8	2	BLIND FLANGE	1 1/2" NPS x 300#	RF		A182 Gr.F9	2.7	5.4	
	9	2	GASKET	1 1/2" NPS x 300#			SS 316L FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER			
	10	8	STUDS	M20 FULL THRD.		95	A 193 Gr.B7	—	—	
	11	16	NUT	M20 HEAVY HEX.		STD	A 194 Gr.2H	—	—	
	18	3	PAD PLT.	5" NPS x SCH.40	BBE	170	A335 Gr.P9	21.7	11.1	
	19	6	STIFF. PLT.	70	10	129	S2062 Gr.E350	—	4.3	
	20	3	STIFF. PLT.	91	10	150	S2062 Gr.E350	—	3.2	
	21	3	PLATE	150	12	150	S2062 Gr.E350	—	6.4	
	25	1	PIPE	5" NPS x SCH.40	BBE	1059.5	A335 Gr.P9	21.7	23.0	
	26	1	PIPE	5" NPS x SCH.40	BBE	1228.5	A335 Gr.P9	21.7	26.7	
	27	1	PIPE	5" NPS x SCH.40	BBE	6209.5	A335 Gr.P9	21.7	135.0	
	28	1	PIPE	5" NPS x SCH.40	BBE	4434.5	A335 Gr.P9	21.7	96.4	
	29	1	PIPE	5" NPS x SCH.40	BBE	1292	A335 Gr.P9	21.7	28.1	
	30	1	PIPE	5" NPS x SCH.40	BBE	134.5	A335 Gr.P9	21.7	2.9	
	WEIGHT								412	
	MK.-116-XO-4	1	1	PIPE	5" NPS x SCH.40	BBE	580	A335 Gr.P9	21.7	12.6
2		1	PIPE	5" NPS x SCH.40	BBE	1368	A335 Gr.P9	21.7	29.7	
3A		1	PIPE	5" NPS x SCH.40	BBE	190.5	A335 Gr.P9	21.7	4.1	
4		1	PIPE	5" NPS x SCH.40	BBE	730	A335 Gr.P9	21.7	15.9	
5		3	ELBOW	5" NPS x SCH.40 x 90°	LR		A234 Gr. WP9	6.5	19.4	
6		2	WELDOLET	5" NPS x SCH.40 x 1 1/2" NPS x SCH.80			A182 Gr.F9	0.5	1.0	
7		2	FLANGE	1 1/2" NPS x SCH.80 x 300#	RFWN		A182 Gr.F9	3.2	6.4	
8		2	BLIND FLANGE	1 1/2" NPS x 300#	RF		A182 Gr.F9	2.7	5.4	
9		2	GASKET	1 1/2" NPS x 300#			SS 316L FOR INNER, OUTER RING & WINDING STRIP, CGI SPIRAL WOUND WITH FLEXIBLE GRAPHITE FILLER			
10		8	STUDS	M20 FULL THRD.		95	A 193 Gr.B7	—	—	
11		16	NUT	M20 HEAVY HEX.		STD	A 194 Gr.2H	—	—	
WEIGHT								95		



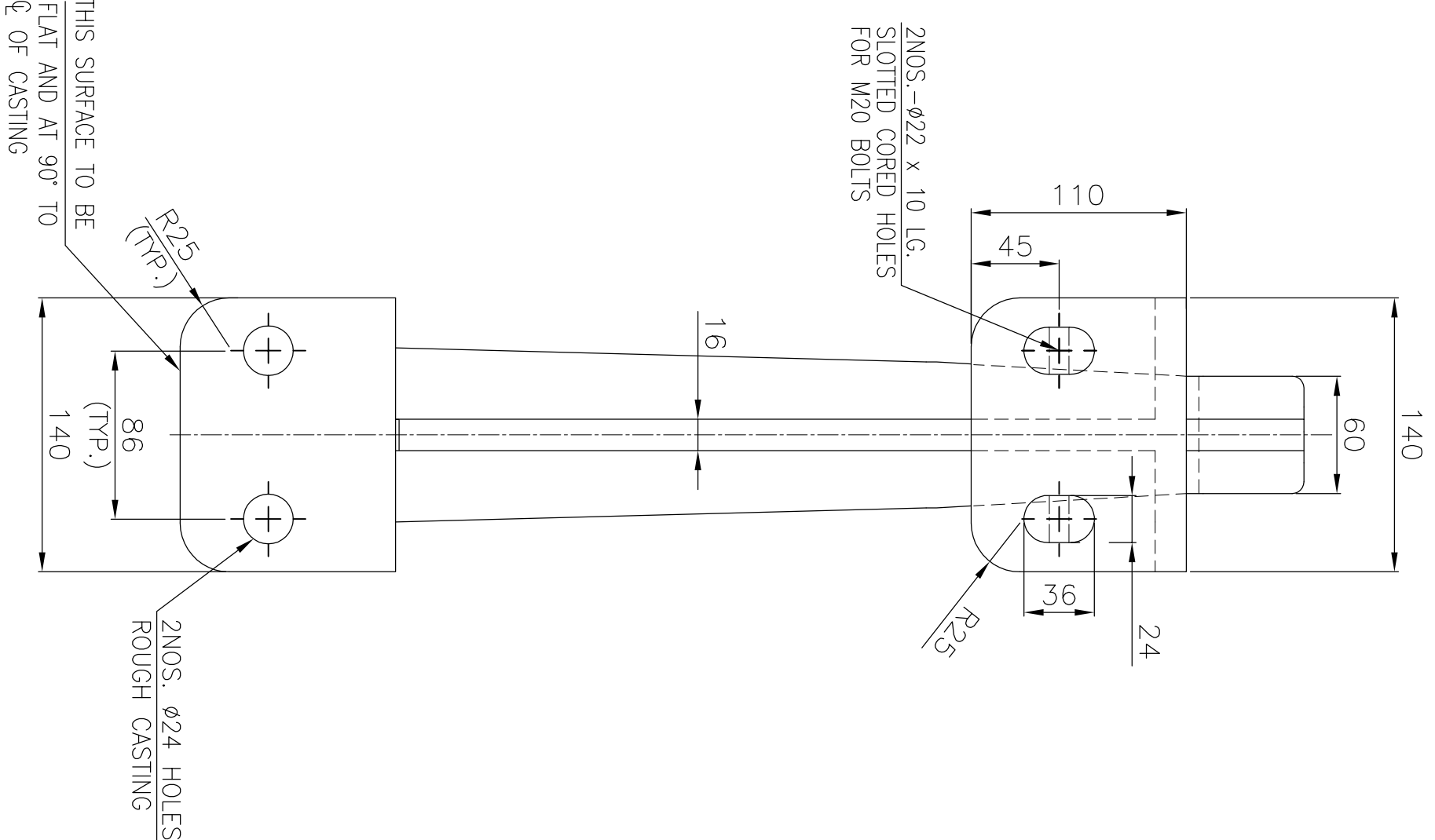
VIEW B-B



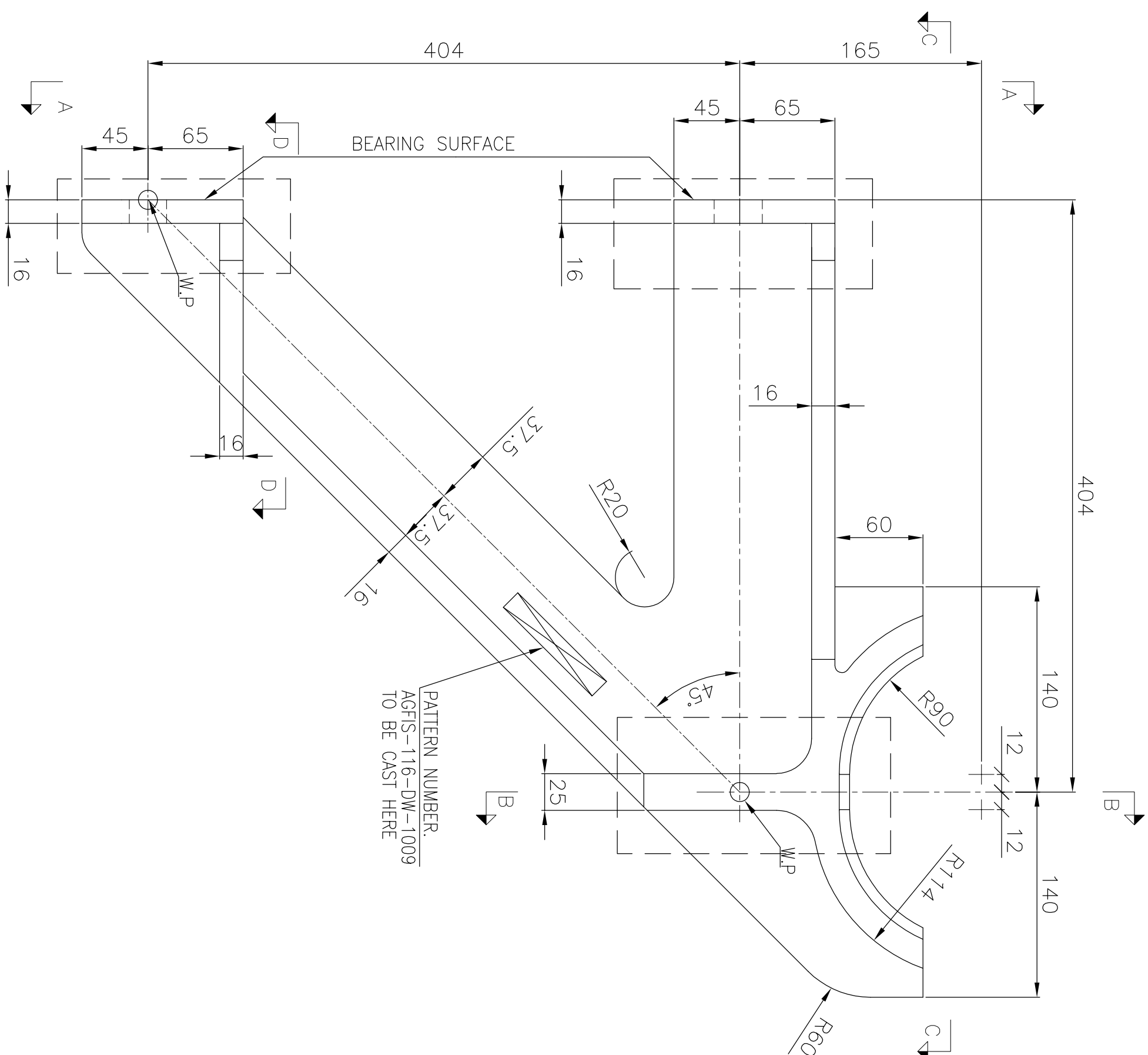
SECTION D-D



VIEW C-C



VIEW A-A



RADIANT TUBE HANGER

NOTES :-

1. ALL DIMENSIONS ARE IN MM UNLESS NOTED OTHERWISE.
2. CASTING MANUFACTURE, TESTING, INSPECTION & SUPPLY SHALL BE IN ACCORDANCE WITH AGFS SPEC. 3-12-023, ELI SPEC. 6-17-007 AND API-5600.
3. ALL TUBE SEATING SURFACES SHALL BE CAST LEVEL & SMOOTH.
4. ALL SHARP CORNERS SHALL BE ROUNDED OFF IN ACCORDANCE WITH GOOD FOUNDRY PRACTICES.
5. MARKING PAINT OR CHALK IF USED SHALL BE FREE OF INGREDIENTS, SUCH AS LEAD, VANADIUM COMPOUNDS, METALLIC ZINC AND ALUMINUM PIGMENTS, WHICH ARE HARMFUL TO AUSTENITIC METAL AT ELEVATED TEMPERATURES. COMMONLY ACCEPTABLE MARKING PAINTS HAVE A TITANIUM OXIDE PIGMENT IN AN ALKYL BASE (NON SULFUR) AND FREQUENTLY HAVE A CALCIUM CARBONATE FILLER.
6. ALL FILET ROUND AND CORED HOLE EDGES TO BE 6 MM RADIUS U.N.O.
7. [.....] INDICATES CRITICAL AREAS OF PRODUCTION CASTINGS TO BE RADIOGRAPHICALLY INSPECTED.
8. VENDOR TO INDICATE THE ACTUAL WEIGHT OF CASTINGS.
9. PATTERN NO. AND MATERIAL GRADE SHALL BE CAST ON THE EXTERIOR SURFACE AT LOCATION SHOWN ON THE DWG.
10. NDE REQUIREMENTS: AS PER AGFS SPEC. 3-12-023R7
ELI SPEC. 6-17-007, & API-5600
11. A) PILOT CASTINGS – RT 100%, DPT 100% & PMI 100%.
12. B) RT OF CRITICAL AREAS OF 6 NO. OF PRODUCTION CASTINGS.
13. C) 100% PT OF ALL THE PRODUCTION CASTINGS.
14. D) 100% PMI OF ALL THE PRODUCTION CASTINGS.

QUANTITY REQ.-28
MAT'L-A351 HK40
ESTIMATED WEIGHT= 30 KG
DESIGN TEMP. = 929°C
DESIGN LOAD = 1437 KG

[illegible]

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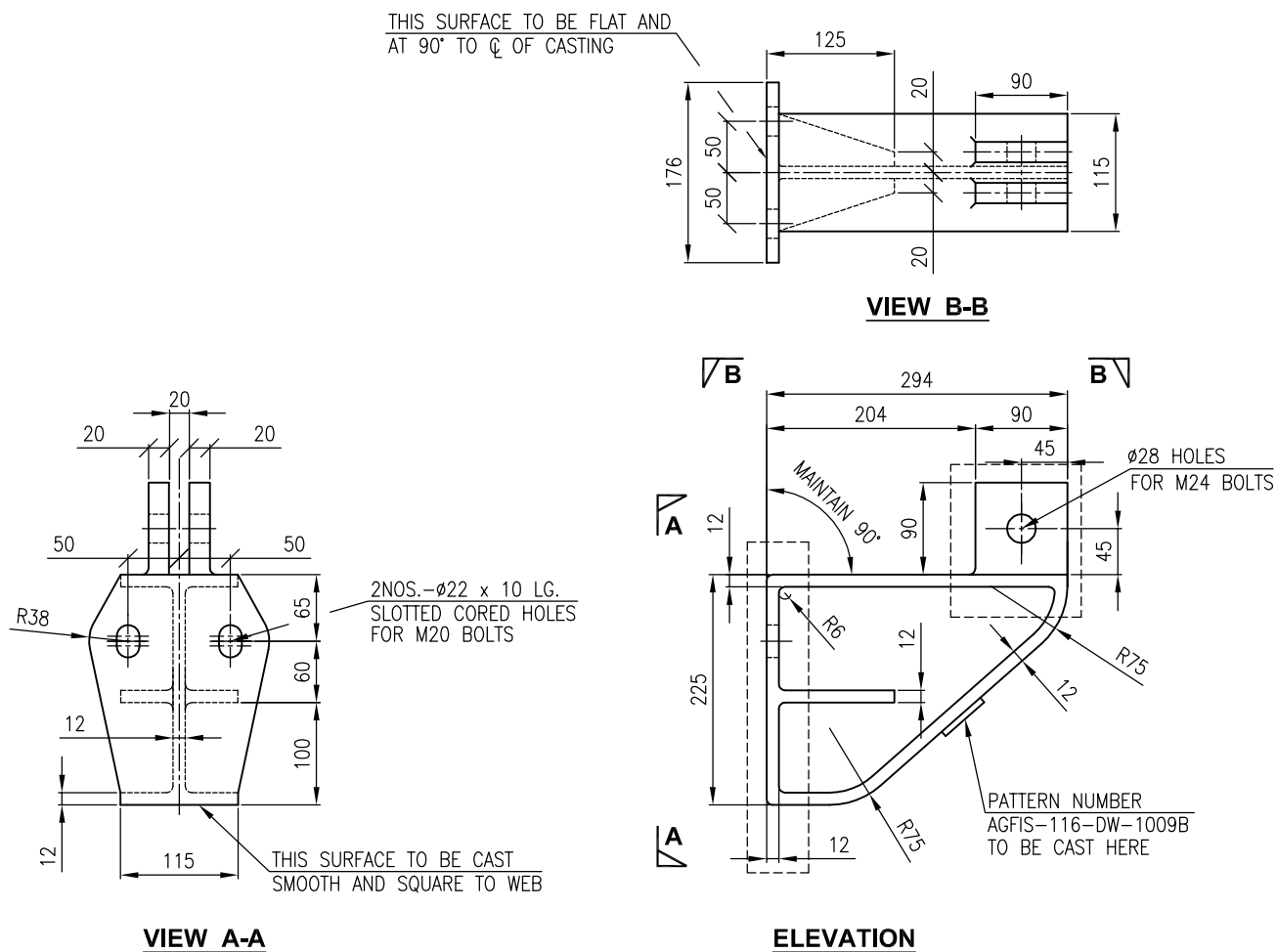
AG FURNACE IMPROVEMENTS PVT. LTD.
NOIDA, INDIA

CLIENT: **BARHAT HEAVY ELECTRICALS LTD.**
HEAVY PLATES & VESSELS PLANT UNIT, WISAKHAPATNAM-530012

FILE : FRESH FEED FURNACE (412-H-1001)
DETAIL OF VERTICAL RADIANT TUBE HANGER
FOR 6" NPS TUBE

SCALE :	DRG.No.	REV.
1 : 3	AGFIS-116-DW-1009A	SHT. 1 OF 1
		0

REV	DATE	DESCRIPTION	DWN	CHKD	APPD
0	26.08.22	ISSUED FOR APPROVAL	SS	ALI	NA



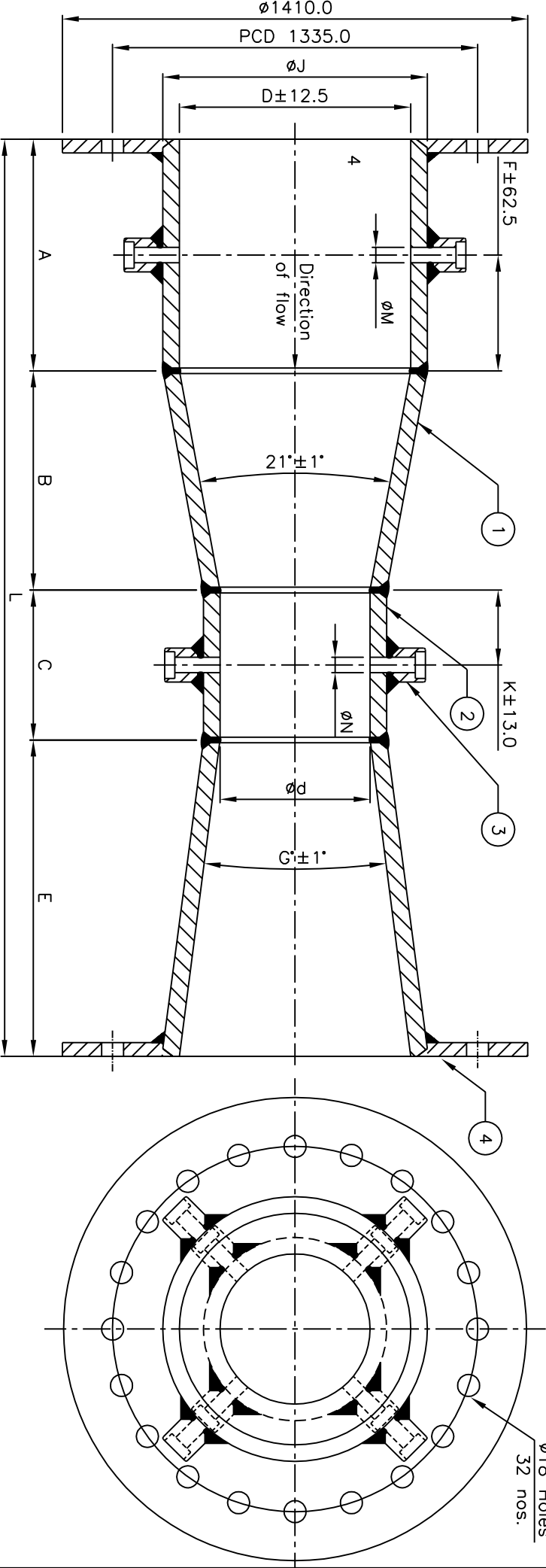
MAT'L - A351 HK40 (25Cr.-20Ni)
QTY REQUIRED - 16 Nos.
APPROX WT. - 17 KG.

DESIGN TEMP. : 929° C
DESIGN LOAD: 753 KG

NOTES :-

1. ALL DIMENSIONS ARE IN MM UNLESS NOTED OTHERWISE.
2. CASTING MANUFACTURE, TESTING, INSPECTION & SUPPLY SHALL BE IN ACCORDANCE WITH AGFIS SPEC 3-12-023, EIL SPEC. 6-17-007 AND API-560.
3. ALL TUBE SEATING SURFACES SHALL BE CAST LEVEL & SMOOTH.
4. ALL SHARP CORNERS SHALL BE ROUNDED OFF IN ACCORDANCE WITH GOOD FOUNDRY PRACTICES.
5. MARKING PAINT OR CHALK IF USED SHALL BE FREE OF INGREDIENTS, SUCH AS LEAD, VANADIUM COMPOUNDS, METALLIC ZINC AND ALUMINUM PIGMENTS, WHICH ARE HARMFUL TO AUSTENITIC METAL AT ELEVATED TEMPERATURES. COMMONLY ACCEPTABLE MARKING PAINTS HAVE A TITANIUM OXIDE PIGMENT IN AN ALKYD BASE (NON SULFUR) AND FREQUENTLY HAVE A CALCIUM CARBONATE FILLER.
6. ALL FILLET ROUND AND CORED HOLE EDGES TO BE 6 MM RADIUS U.N.O.
7. [] INDICATES CRITICAL AREAS OF PRODUCTION CASTINGS TO BE RADIOGRAPHICALLY INSPECTED.
8. VENDOR TO INDICATE THE ACTUAL WEIGHT OF CASTINGS.
9. PATTERN NO. AND MATERIAL GRADE SHALL BE CAST ON THE EXTERIOR SURFACE AT LOCATION SHOWN ON THE DWG.
10. NDE REQUIREMENTS: AS PER AGFIS SPEC. 3-12-023R7 EIL SPEC. 6-17-007, & API-560
 - A) PILOT CASTINGS - RT 100%, DPT 100% & PMI 100%.
 - B) RT OF CRITICAL AREAS OF 4 NO. OF PRODUCTION CASTINGS.
 - C) 100% PT OF ALL THE PRODUCTION CASTINGS.
 - D) 100% PMI OF ALL THE PRODUCTION CASTINGS.

Sr.No.	Tog No./Service	D	J	d	Tol.	A	B	C	E	L	F	K	M	N	G	Qty.
1	412-FE-2341	1250.00	1260.0	652.5	±0.65	1250.0	1611.6	652.5	2432.7	5946.8	625.0	326.2	8.0	8.0	14	1



Notes

- 1) The venturi shall be stamped with 1. The tog no., 2. The nominal pipe size, 3. The diameter of venturi, 4. The material of the venturi
- 2) Upstream & Downstream straight length shall be 4D & 4d respectively.
- 3) Approximate weight of the flow element shall be 1000 kg.

OA NO.C23003

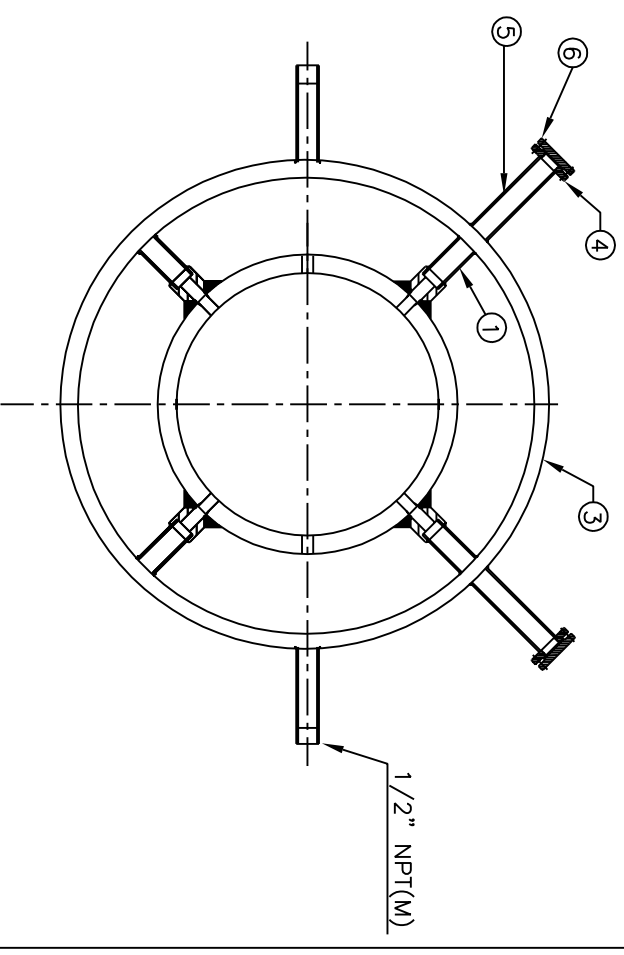
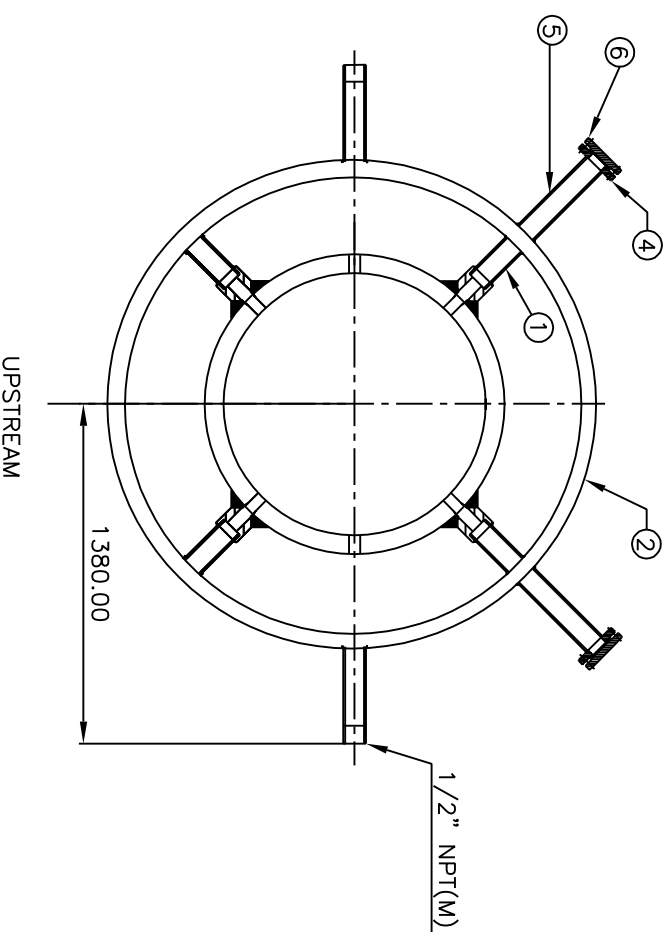
Sr.No.	Description	Material	Qty.
4	Plate Flange(8.0mm Thk)	IS 2062	2
3	Half coupling, SW 15 NB 3000 Psi	A 105/A 106-B	4
2	Venturi Throat	SS 316	1
1	Venturi body	IS 2062-B	1

PROJECT -		CONSULTANT -		CUSTOMER - BHEL	
ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.					
2	Note 2	19.07.23			
1	CHANGE IN MAT.	25.05.23			
0	-	09.03.23			
NO	CHANGE	DATE	CHK.	APP.	
SCALE - NTS		SHEET 1 OF 1		DRG. NO. M575	
				R 2	

STAR-MECH
CONTROLS (I) PVT. LTD.



TITLE VENTURI



7	Gasket 1/2" 150#	AF 120	4
6	FLANGE BLRF B16.5a 1/2" 150#	A182-F316	4
5	Nipple 1/2" sch-80 PE L=120 MM	A312-TP316	8
4	FLANGE SORF B16.5a 1/2" 150#	A182-F316	4
3	Ring (THROAT) 25 NB L(approx)=2273.0 MM	A312-TP316	1
2	Ring (UPSTREAM) 25 NB L(approx) = 3671.0 MM	A312-TP316	1
1	Nipple 1/2" sch-80 PE L=100	A312-TP316	8

- Notes
- 1) Stud for spare tapping 1/2" UNC-2A in A 193-B7 QTY. 16 nos. shall be provided.
 - 2) Nut for spare tapping 1/2" UNC-2B in A 194-2H QTY. 32 nos. shall be provided.

DWG NO. M575-1
OA NO. C23003
Sheet 2 of 2

DOCUMENT CATEGORY		DOCUMENT REVIEW STATUS (BY CLIENT)				
(USE "X" MARK) APPROVAL X REVIEW INFORMATION		thyssenkrupp Industrial Solutions 1 APPROVED This approval does not release the vendor / supplier from full responsibility for his design and fabrication. Date: June 9, 2023 Name: Khushalani, Manoj				
RETAINED FOR INFORMATION						
Painting procedure to be submitted for scope and method, reference doc., how to carry out surface preparation, application of paint, inspection and testing as per project specification. Standard paint report format covering all paint requirements to be supported for reference..						
00	17.04.23	NIL	KK	S V	ESNP	
REV	DATE	DETAILS OF REVISION	PREPARED	CHECKED	APPROVED	
CLIENT	INDIAN OIL CORPORATION LIMITED PANIPAT REFINERY					
CONSULTANT	THYSSENKRUPP INDUSTRIAL SOLUTIONS, INDIA PVT. LTD. (tkIS-India)					
PROJECT	FIRED HEATER FOR INDMAX UNIT OF PANIPAT REFINERY EXPANSION (P-25) PROJECT					
ESC	AG FURNACE IMPROVEMENTS PVT. LTD. NOIDA, INDIA					
 BHEL VISAKHAPATNAM			NAME	SIGN	DATE	
		DRN	KK	-sd-	17.04.23	
		CHD	SV	-sd-	17.04.23	
		APPD	ESNP	-sd-	17.04.23	
The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED , It must not be used directly or indirectly in any way detrimental to the interest of the company		TITLE: PAINTING SCHEDULE FOR HEATER & APH				
		BHEL DOC No. 7935-PSCH-001				REV
		CUST. DRG/ DOC NO. 6745-PRC-412-DZ-0002-008				00
		SHT NO. 01		NO. OF SHT. 3		



Painting Schedule for INDMAX Heater Package (412-H-001), IOCL Panipat

Doc. No.: 6745-PRC-412-D2-0002-008/ R0

Paint schedule to meet requirements in accordance with PR spec: 6745-EQS-000-EC-0003 ; R01

Sl. No.	DESCRIPTION	SURFACE PREPARATION & PROFILE	Temp. applicable (°C)	Coating type/ system	PRIMER COAT		INTERMEDIATE Coat		FINISH COAT		TOTAL DFT µm/min	Color code
					PAINT	NO OF COATS / DFT	PAINT	NO OF COATS /DFT	PAINT	NO OF COATS / DFT		
1	External surfaces of Heater Casing plate, Columns and structural stiffeners in contact with heater casing & Stack shell with stiffeners, Air Duct (Cold, Bypass & Hot), Flue Gas Duct, H/Box plate, Duct stiffeners and supports	Abrasive Blast Clean to Sa 2 ^{1/2}	>0 and ≤120	i	Inorganic zinc silicate @65-75µm	1	High Build Epoxy MIO @100-150µm	1	Two Pack acrylic polyurethane @40-50µm	1	205-275	HR Aluminum RAL 9006
2	Stair tower & APH support structure and platform support beams, & misc. structures	Abrasive Blast Clean to Sa 2 ^{1/2}	>0 and ≤120	i	Inorganic zinc silicate @65-75µm	1	High Build Epoxy MIO @100-150µm	1	Two Pack acrylic polyurethane @40-50µm	1	205-275	Steel Gray RAL 7011
3	Hand Rails	SSPC-SP-10	≤80	Hot dip galvanizing+ spray paint	Hot Dip Galvanizing to 80-85 microns as per IS 4736 + 1 coat of Inorganic zinc silicate @65-75µm		-		Two Pack acrylic polyurethane @40-50µm	1	105-125 (Excluding galvanizing)	Signal red RAL 3001
4	Heater inside surface in contact with Ceramic Fiber	Abrasive Blast Clean to Sa 2 ^{1/2}	-	j	Epiplus-56 of Shalimar or Equivalent@ 90-100 microns each	2	-	-	-	-	180-200	-
5	Gratings	SSPC-SP-10	≤80	Hot dip galvanizing+ spray paint	Hot Dip Galvanizing to 80-85 microns as per IS 4736 + 1 coat of Inorganic zinc silicate @65-75µm		-		Two Pack acrylic polyurethane @40-50µm	1	105-125 (Excluding galvanizing)	Black RAL 9005
6	Staircase stringers, Ladders and Walkways	Abrasive Blast Clean to Sa 2 ^{1/2}	>0 and ≤120	i	Inorganic zinc silicate @65-75µm	1	High Build Epoxy MIO @100-150µm	1	Two Pack acrylic polyurethane @40-50µm	1	205-275	Black RAL 9005
7	MP steam piping IBR, INSULATED	Abrasive Blast Clean to Sa 2 ^{1/2}	>200	l	-	-	-	-	HR Aluminum/ Silicon Aluminum @15-20µm	2	30-40	OFF White/ Aluminum with 1 red strip RAL9006/3001
8	LP Steam Piping IBR, INSULATED	Abrasive Blast Clean to Sa2 ^{1/2}	>200	l	-	-	-	-	HR Aluminum/ Silicon Aluminum @15-20µm	2	30-40	OFF White/Aluminum with 1 green strip RAL 9006/6021
9	Feed/ Hot Oil Piping	Abrasive Blast Clean to Sa 2 ^{1/2}	>200	i	-	-	-	-	HR Aluminum/ Silicon Aluminum @15-20µm	2	30-40	Dark Ad. Grey Ground Color with 1 red strip RAL 7012/3002
10	Fuel Gas	Abrasive Blast Clean to Sa 2 ^{1/2}	>120 and <200	i	Inorganic Zinc silicate @65-75µm	1	-	-	Two Pack Epoxy Phenolic @150µm	2	365-375	Orange with 1 Aluminum strip RAL 2011/9006
11	CONDENSATE IBR, INSULATED	Abrasive Blast Clean to Sa 2 ^{1/2}	>120 and <200	i	Inorganic Zinc silicate @65-75µm	1	-	-	Two Pack Epoxy Phenolic @150µm/Coat	2	365	Sky Blue with 1 white strip RAL 5015/9010

S.No.	DESCRIPTION	SURFACE PREPARATION & PROFILE	Temp. applicable (°C)	Coating type/ system	PRIMER COAT		INTERMEDIATE COAT		FINISH COAT		TOTAL DFT μm/mi n	Color code
					PAINT	NO OF COATS / DFT	PAINT	NO OF COATS/DFT	PAINT	NO OF COATS / DFT		
12	Plant air / Service air UNINSULATED	Abrasive Blast Clean to Sa 2 ^{1/2}	UPTO 120°C	i	Inorganic Zinc silicate @65-75μm	1	High Build Epoxy MIO @100-150μm	1	Two Pack acrylic polyurethane @40-50μm	1	205	Sea Green with 1 signal red strip RAL 6018/3001
13	Instrument air UNINSULATED	Abrasive Blast Clean to Sa 2 ^{1/2}	UPTO 120°C	i	-	-	-	-	Two Pack Epoxy Phenolic @150μm **	-	-	Sea Green with 1 signal black strip RAL 6018/9005
14	Cooling water UNINSULATED	Abrasive Blast Clean to Sa 2 ^{1/2}	UPTO 120°C	i	Inorganic Zinc silicate @65-75μm	1	High Build Epoxy MIO @100-150μm	1	Two Pack acrylic polyurethane @40-50μm	1	205	Sky blue with 1 light brown strip RAL 5015/1011
15	Nitrogen UNINSULATED	Abrasive Blast Clean to Sa 2 ^{1/2}	UPTO 120°C	i	Inorganic Zinc silicate @65-75μm	1	High Build Epoxy MIO @100-150μm	1	Two Pack acrylic polyurethane @40-50μm	1	205	Milky white RAL 9016
16	Connection to Flare lines	Abrasive Blast Clean to Sa 2 ^{1/2}	Intermittent temperatures	i	-	-	-	-	Aluminum Finish point (IS-2339) @ 15-20μm	2	30	RAL9006 Aluminum
17	Light Flushing Oil INSULATED	Abrasive Blast Clean to Sa 2 ^{1/2}	>120 and <200	i	Inorganic Zinc silicate @65-75μm	1	-	-	Two Pack Epoxy Phenolic @150μm	2	365	Oxide Red with 2 black strips RAL 3009/9005
18	Drinking water	Abrasive Blast Clean to Sa 2 ^{1/2}	UPTO 120°C	i	Two pack epoxy phenolic@150μm	2	-	-	-	-	300	Sky blue with 1 Green strip RAL 5015/6010

Notes:

- All primers and finish coats should be ambient temperature curing and air drying unless otherwise specified.
- For Stack inside shell, 3mm Coating of potassium silicate mortar (as per IS 4832 part-1) before application of castable lining (supply & application by Refractory vendor)
- (*) -Radiant Shell Inside Surface & Flue Gas Duct Inside Surface – Paint is in scope of Insulation & Refractory Vendor scope.
- Radiant:
 - Sidewalls & Arch : CF Module 1425°C grade & CF Blanket
Floor: Refractory Fire Bricks + Castable Insulyte 11 + Castable Insulyte 7
- Convection:
 - Sidewalls: Castable Insulyte 8S + Castable Insulyte 7
 - Breeching: Castable Insulyte 8S
- Stack:
Castable Insulyte 11
- Ducting:

- HFG – - CFG – - Hot Air Ducts – - BP Duct –	}	will be provided as per vendor selection.
--	---	---
- ** : The Finish Paint indicated is only for band strip.

DOCUMENT CATEGORY		DOCUMENT REVIEW STATUS (BY CLIENT)				
(USE "X" MARK) ☒ APPROVAL ☐ REVIEW ☐ INFORMATION						
RETAINED FOR INFORMATION KINDLY GET THE SAME REVIEWED WITH TKIS SITE TEAM BEFORE EXECUTION						
00	30.11.22	NIL	P. Gopi Kishore	Amiya Krishna Mandal		
REV	DATE	DETAILS OF REVISION	PREPARED	CHECKED	APPROVED	
CLIENT	 INDIAN OIL CORPORATION LIMITED PANIPAT REFINERY					
CONSULTANT	 THYSSENKRUPP INDUSTRIAL SOLUTIONS, INDIA PVT. LTD. (tkIS-India)					
PROJECT	FIRED HEATER FOR INDMAX UNIT OF PANIPAT REFINERY EXPANSION (P-25) PROJECT					
ESC	 AG FURNACE IMPROVEMENTS PVT. LTD. NOIDA, INDIA					
 BHEL VISAKHAPATNAM			NAME	SIGN	DATE	
		DRN	PGK	-sd-	30.11.22	
		CHD	AKM	-sd-	30.11.22	
		APPD	AKM	-sd-	30.11.22	
The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company		TITLE: QAP for Site Activities				
		BHEL/AGFIS DRG/DOC No. CQP 2535				REV
		CUST. DRG/ DOC NO. 6745-PRC-412-DZ-0002-080				00
		SHT NO. 01		NO. OF SHT. 9		

		MANUFACTURER'S NAME & ADDRESS BHEL-VISAKHAPATNAM or Approved Sub-Contractor		SITE ACTIVITIES QUALITY PLAN ITEM: Fresh Feed Furnace QP NO: CQP 2535 Rev 00 TAG No: 412-H-1001 Date: 30.11.2022 PAGE 1 of 8			PROJECT: IOCL, Panipat INDMAX Unit PACKAGE: Fired Heater SO NO: 7935 Customer FOA: RHQPJ/2022-2023/EPDCM2/FOA/04 Dt. 22-07-2022					
SL No	COMPONENT & OPERATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD		AGENCY			REMARKS
									M	C	N	
1	2	3	4	5	6	7	8	D				

1.0	INCOMING MATERIALS VERIFICATION (Material, Equipment, Pre-Fabricated and Bought Out Items)											
1.1	Radiant coils, Convection coils Crossover lines etc.,	Mechanical Chemical NDT as applicable	Records verification	100%	BHEL Drawing	Mfg TC/ Material Data Report	✓	P	QC	R	Refer Note-3	
1.2	Bought Out Items / Direct dispatches	Mechanical Chemical NDT as applicable	Records verification	100%	BHEL Drawing	Mfg TC/ Material Data Report	✓	P	QC	R	Refer Note-3	
1.3	Refractory & Insulation items etc.,	Mechanical Chemical NDT as applicable	Records verification	100%	BHEL Drawing	Mfg TC As applicable	✓	P	QC	R	Refer Note-3	
1.4	Items like Piping, non-pressure parts like Structural and Stack, Other Miscellaneous Materials / Items as per respective material specification / BHEL Drawing(s).					-	✓	P	QC	R	Refer Note-3	
1.5	Consumable Items like Paints, Welding electrodes etc. as per respective material specification and BHEL Drawing(s) as applicable.					-	-	P	QC	-	(Check on sample basis)	

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		MANUFACTURER'S NAME & ADDRESS BHEL-VISAKHAPATNAM or Approved Sub-Contractor		SITE ACTIVITIES QUALITY PLAN			PROJECT: IOCL, Panipat INDMAX Unit PACKAGE: Fired Heater SO NO: 7935 Customer FOA: RHQPJ/2022-2023/EPDCM2/FOA/04 Dt. 22-07-2022					
				ITEM: Fresh Feed Furnace TAG No: 412-H-1001								QP NO: CQP 2535 Rev 00 Date: 30.11.2022 PAGE 2 of 8
SL No	COMPONENT & OPERATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD		AGENCY			REMARKS
								D	M	C	N	
1	2	3	4	5	6	7	8					

2.0	PRE-FABRICATION ACTIVITIES										
2.1	Calibration of Test / Measuring Instruments	Validity	Records verification	100%	Drawings / Specification	Reports / Records	V	P	QC	V	
2.2	Welding Equipment , accessories and tools & tackles	Functionality / Validity	Records verification	100%	Drawings / Specification	Reports / Records	-	P	QC	R	
2.3	Welding Qualification	Procedure Qualification	WPS Review	100%	ASME Sec IX as applicable	WPS PQR	-	P	QC	V	
2.4	Welder Qualification	Personnel Qualification	WQR Review	100%	AWS/IBR/IS (#)	WQR	-	P	QC	V	# As applicable
2.5	Approved drawings, NDE & Welding procedures, Painting specification	Availability before start of work	Review	100%	Drawings / Specification	Records	-	P	QC	V	(as applicable)
2.6	Material traceability	Identity	Verification	100%	Drawings / Specification	Records	-	P	QC	V	
2.7	PMI (only for SS and Alloy Steels)	Properties	Verification	100%	Drawings / Specification	Records	-	P	QC	V	(as applicable)

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SL No	COMPONENT & OPEARATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD		AGENCY			REMARKS
									M	C	N	
1	2	3	4	5	6	7	8	D				

3.0	FABRICATION INPROCESS INSPECTION and NDE (Refer Execution Philosophy enclosed)											
3.1	Edge preparation of welds	Soundness	Visual & LPI	100%	BHEL Drawing	Report	v	P	QC & NDT	-		
3.2	Fit up inspection	Weld angle, mis-match, root gap etc.	Visual & Dimension	100%	BHEL Drawing	Report	v	P	QC	R		
3.3	Pre heat as per WPS	Temperature	Verification	100%	Drawing / WPS / Specification	Report	v	P	QC	R		
3.4	PT of Root and final welds of all butt and fillet joints	Soundness	PT	100%	Customer Specification	PT Report		P	NDT	*	*Random check	
3.5	PWHT as per WPS	Time & Temperature	Verification	100%	Drawing / WPS / Specification	Report/ Chart	v	P	QC	V		
3.6	Hardness check (if applicable) as per WPS after PWHT	Hardness	Verification	100%	Drawing / WPS / Specification	Report	-	P	QC	V		
3.7	Weld Visual before RT	Soundness	Visual	100%	As per drawing	Report		P	QC	-		

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	BHEL-VISAKHAPATNAM or Approved Sub-Contractor		ITEM: Fresh Feed Furnace TAG No: 412-H-1001		QP NO: CQP 2535 Rev 00 Date: 30.11.2022 PAGE 4 of 8					

SL No	COMPONENT & OPEARATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY			REMARKS
								M	C	N	
1	2	3	4	5	6	7	8	D			

3.8	RT of Butt welds in Radiant & Convection coils, Cross-over lines etc.,	Soundness	RT	100%	Customer Specification	RT Report	V	P	NDT	V	V-Random check
3.9	Surface preparation & Painting	Visual, DFT etc.,	Verification	100%	Customer Specification & BHEL Drawing / Painting Specification	Painting report	V	P	QC	W	
4.0	ERECTION										
4.1	Lifting Arrangement	Adequacy	Verification	100%	Customer Specification & BHEL Drawing / Specifications	-	V	P	QC	R	
4.2	Inspection of foundation for cleanliness	Free from foreign materials	Verification	100%	Customer Specification & BHEL Drawing / Specifications	Report	-	P	QC	R	
4.3	Alignment & Levels / Correctness of Location & orientation of branches / bracing, lugs, ladders etc	Dimensions	Verification	100%	Customer Specification & BHEL Drawing	Report	V	P	QC	W	

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	BHEL-VISAKHAPATNAM or Approved Sub-Contractor		ITEM: Fresh Feed Furnace TAG No: 412-H-1001		QP NO: CQP 2535 Rev 00 Date: 30.11.2022 PAGE 5 of 8					

SL No	COMPONENT & OPEARATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY			REMARKS
								M	C	N	
1	2	3	4	5	6	7	8	D			

4.4	Fit up and Dimensional Check	Alignment, mismatch etc.	Visual & Dimension	100%	BHEL Drawing	Report	√	P	QC	RW	
4.5	Provision of instrument tappings, vents, drains, Lapping of RTJ flange face gasket etc as applicable	Correctness	Visual	100%	As per drawing	Report	-	P	QC	V	
4.6	Weld Visual	Soundness	Visual	100%	As per drawing	Report	-	P	QC	R	
4.7	Correctness of type of support, anchor, guides etc., Gaskets and fasteners, Valves and steam traps as applicable.	Correctness	Visual	100%	As per drawing	Report	√	P	QC	R	
4.8	Bolt tensioning / Torqueing / Manual tightening as applicable	Correctness	Visual	100%	As per drawing	Report	-	P	QC	R	

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SL No	COMPONENT & OPEARATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY			REMARKS
								M	C	N	
1	2	3	4	5	6	7	8	D			

5.0	REFRACTORY & INSULATION WORK										
5.1	Clearance prior to start of Refractory work	Mechanical Completeness	Visual, Measurement	100%	BHEL Drawing, tKIS Specification & approved Drawings as applicable	Inspection Report	√	P	QC	W	
5.2	Refractory application & Dry out	Completeness	Visual, Measurement	100%	Approved Refractory Procedure, Execution Philosophy, tKIS Specification as applicable	Inspection Report	√	P	QC	W	
5.3	Clearance prior to start of Insulation work	Mechanical Completeness	Visual, Measurement	100%	BHEL Drawing, tKIS Specification & approved Drawings as applicable	Inspection Report	√	P	QC	W	.
5.4	Insulation application										

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	BHEL-VISAKHAPATNAM or Approved Sub-Contractor		ITEM: Fresh Feed Furnace TAG No: 412-H-1001		QP NO: CQP 2535 Rev 00 Date: 30.11.2022 PAGE 7 of 8					

SL No	COMPONENT & OPEARATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD	AGENCY			REMARKS
								M	C	N	
1	2	3	4	5	6	7	8	D			

6.0	FINAL INSPECTION & TESTING										
6.1	Visual & Dimensional check	Visual & Dimensions	Visual Measurement	100%	BHEL Drawing	Inspection Report	√	P	QC	W	
6.2	Flushing and cleaning	Free from debris / foreign objects	Verification	100%	Customer Specification & BHEL Drawing	Report	√	P	QC	W	
6.3	Hydro test, Draining and Drying	Soundness	Visual & Leak check	100%	Customer Specification & BHEL Drawing	Hydro test report	√	P	QC	W	Refer Note 1
6.4	Surface preparation & Painting	Visual, DFT	Verification	100%	Customer Specification & BHEL Drawing / Painting Specification	Painting report	√	P	QC	W	
6.5	Spares (as applicable)	Availability	Verification	100%	Customer Specification & BHEL Drawing	Reports	√	P	QC	W	IRN to be issued by TPI.
6.6	Document Folder	Documents	Verification	100%	Customer Specification & BHEL Drawing	Records		P	QC	V	

NOTES:

- 1) Hydro test of only Radiant coils & convection coils will be done after completion of site welds. After hydro test in coils, dry / hot air shall be used for cleaning.
- 2) Quality Plan for Supplied Items (CQP 2519 Rev.00) in line to point no.26 of KOM MOM Dt. 22-01-2021 submitted separately.
- 3) Dispatch Instruction (DI); Inspection Release Notes to be produced for IMIR Clearance excluding consumables i.e Paints, Welding electrodes etc.

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SL No	COMPONENT & OPERATION	CHARACTERISTICS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	FORMAT OF RECORD		AGENCY			REMARKS
1	2	3	4	5	6	7	8	D	M	C	N	

LEGEND:

P: Perform	TDC: Technical Delivery Condition	PQR: Procedure Qualification Record	QC: Quality Control
R: Review	TC: Test Certificate	WQR: Welder Qualification Record	NDT: Non-Destructive Testing
W: Witness	AWS: American Welding Society	RT: Radiographic testing;	M: BHEL/Approved sub-contractor
RW: Random Witness	WPS: Welding Procedure Specification	LPI: Liquid Penetrant Inspection	C: BHEL /Authorized Field Quality Control Engineer
V: Verification	For clauses marked with (TICK) in "D", Certificates shall be included in Documentation.	PMI: Positive Material Identification	N: TPIA Representing Customer (appointed by BHEL as per present contract)

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EXECUTION METHODOLOGY for FIRED HEATER

RADIANT SECTION:

- Fabrication of Radiant columns & casing wall panels of Radiant section including Surface preparation and application of Primer paint at HPVP. The Radiant Columns and casing Wall panels will be dispatched to site in loose condition as per Modularization philosophy.
- Erection of columns on Foundations and erection of Casing wall panels to form the Radiant Box. Fit up and welding of Wall panels to form complete Radiant casing at site.
- Fabrication of Radiant Arch and Floor in segments as per Modularization philosophy including Surface preparation and application of Primer paint at HPVP. These Arch and Floor segments will be dispatched to site.
- Fabrication of Radiant platforms, staircase, ladders, Handrails etc. at HPVP and dispatch to site in loose DU's.
- Fabrication of Radiant Outlet Header (24"), cross over & jump over coil spools, Sight doors, Instrument nozzles, Tube pulling door, Explosion door, breeching access door etc. at HPVP and will be dispatched to site.
- Erection and welding of Arch and Floor plates of the Radiant section at site.
- Marking and cutting openings in Radiant section for fixing and welding of Sight doors, Instrument nozzles, Tube pulling door, Explosion door, access door etc. at site. Installation and welding / fixing of these Sight doors, Instrument nozzles, Tube pulling door, Explosion door, access door etc.
- Radiant hanger supports received as BOC 's at HPVP will be dispatched to site. Erection and Alignment of Radiant coil hanger supports will be done prior to the erection of radiant coils.
- After completion of all the welding, Mechanical clearance will be obtained for Installation of Refractory lining in the Radiant section.
- Application of refractory Lining in the Radiant walls as per approved Refractory lining procedure.
- Fabrication of Radiant Coils in Banjos at HPVP including NDT as per QAP in line with Modularization philosophy and dispatched to site. Radiant coils banjos are inserted through the Arch opening and erected inside Radiant section along with coil hangers at site.
- Alignment, fit up and Welding and NDT of site weld joints of Radiant coils including weld joints of the coil joints with radiant manifold.
- Application of balance Refractory in wall and Arch portion after obtaining mechanical completion in Radiant section.

- Marking and cutting openings on Radiant floor for fixing of Burners, peep holes, spigot pipes etc. at site and installation of Peep holes and other auxiliary assemblies in the Floor excluding Burners.
- Trail assembly of Burners in the Floor plate will be done and removed for application of Floor Refractory after the completion of Radiant coil assembly and welding and hydro test.
- Floor Refractory will be carried out as per approved refractory procedure.
- Burners will be installed after the completion of the refractory lining.

CONVECTION SECTION:

- Fabrication of Convection Sections including Refractory lining and Coils will be done in Two Modules as per Modularization philosophy at HPVP.
- Fabrication of Convection modules consisting of casing, supporting structure, ITS castings, ETS, Header Boxes, Instrument nozzles, OBDs, Breeching Access doors, Retainer plates etc. at HPVP.
- After Hot work is completed in the Convection Modules, Mechanical clearance will be obtained for releasing the Modules for refractory lining.
- Refractory lining in both the Modules will be done at HPVP as per the approved procedure.
- Fabrication of Header boxes and ETS in panels along with Refractory lining and assembly with convection section at HPVP.
- Dry Out of the Refractory lining in Convection Modules, if applicable, will be carried out after completion of refractory lining as per approved procedure.
- Prefabrication of Convection coils (J sticks form) including all NDT as per QAP will be carried out simultaneously so that the same are ready for Insertion in the Convection Modules after the Refractory application and dry out is completed.
- The Prefabricated Convection coils will be inserted in the Convection Modules and Assembly, fit up and welding of site joints including NDT as per QAP will be carried out.
- The convection modules will be dispatched to site in TWO Modules.
- Erection and welding of convection Module-I on the Radiant section at site.
- Erection and welding of convection Module-II on convection Module-I at site.
- Refractory lining at Joint of Module I and Module –II will be carried at site after Welding.
- Erection and welding of convection off-take duct along with Damper on convection section at site.
- Fabrication of Convection & Stack supporting structure, platforms, ladders, Handrails etc. at HPVP and dispatched to site in loose DU's.

- Erection, Fit up and welding of convection and stack supporting structure, Platforms & staircase structures, ladders and handrails at site.
- Erection and welding of cross over coils i.e., convection outlet to Radiant inlet and Jump over coils i.e., in between convection Module-I to Module-II at site.
- Hydro test of Radiant and convection coils at site.
- Erection and fixing of Header boxes with convection section after Hydro test of Coils at site.
- Application of external insulation of Coils, manifold at site.

STACK

- Fabrication of Stack in 3 sections with refractory application and Dry out at HPVP as per Modularization philosophy and sent to site.
- Fabrication of Stack Modules including Rolling, Fit up and assembly of shell sections, Instrument tapping points, Wind Strakes, Supporting structure for Paint trolley and applicable NDT at HPVP in THREE Modules.
- Mechanical clearance to be obtained and release for Refractory in the Stack modules.
- Application of refractory lining and Dry out of the Refractory lining of Three Modules of Stack.
- Fabrication of Stack platforms, ladders, Handrails etc. at HPVP and dispatched to site in loose DU's.
- Erection, alignment and welding of Stack sections on the supporting structure.
- Erection of Stack supporting structure, platforms, ladders, Handrails etc. at site.
- Refractory lining at Joint of Stack Module I, II & III will be carried at site after completion of welding of site joints.

FD Fans, ID Fans, CAPH and Steam APH

FD Fans, ID Fans, CAPH and Steam APH will be recd. at site from Vendors as BOC's as per approved Modularization philosophy.

The fabrication of supporting structure for CAPH and Steam APH will be carried out at HPVP and dispatched to site in loose DU's. The erection, alignment and welding of supporting structures will be carried out at site.

Erection, Alignment and Grouting of CAPH and Steam APH will be carried out on the supporting structure at site as per approved QAP.

Erection, Alignment and Grouting of FD Fans and ID Fans will be carried out at site as per approved QAP. Further activities like Installation of Motor, Alignment of Motor with Fan, Decoupled/ Idle Run of Motor etc. will be carried and Fans will be made ready for Couple run.

Off take Ducts, Cold Air, Hot air, Bypass, Hot Flue Gas Ducts:

Fabrication of Cold Air, Hot air, Bypass, Hot Flue Gas Ducts in segments as per the Modularization philosophy will be done at HPVP.

- Fabrication of Cold Air, Hot air, Bypass, Hot Flue Gas Ducts in segments as per the Modularization philosophy will be done at HPVP.
- After completion of Fabrication of Hot Flue gas ducts, Refractory lining will be carried out at HPVP and dry out will be carried out as per approved procedure.
- The Ducts after completion of fabrication and refractory lining & dry out, wherever applicable, will be dispatched to site.
- Erection of Interconnecting Ducts between FD Fans, ID Fans, CAPH and Steam APH will be carried out.
- Application of external insulation Hot Air Ducts at site.