`TECHNICAL DOCUMENTATION FRONT SHEET

Total Pages: 24

**NUMALIGARH REFINERY LIMITED**

# NRL EXPANSION PROJECT

## Post Weld Heat Treatment Procedure for C3 Splitter #1(1P25-CC-3127)

Vendor Name: Fabtech Projects and Engineers Ltd
Tag / Item No.:1P25-CC-3127
Tag / Item Description: C3 SPITTER #1

**tkIS India / Vendor**

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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- ☐ 6 Reviewed as Noted / Resubmit

**Remarks for AC2 :** This marked-up drawings is hereby approved for fabrication / manufacturing and shall be re-sbumitted after revision. This drawing should be revised only to the extent of tkIS India / Owner / Client comments. Any other changes made by you will not be considered unless clearly highlighted in covering letter asking for approval.

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Date : ___/___/_____ Name : _____

| Rev | Date | Reason for Issue | Prepared | Checked | Approved | Prepared | Review | Review |
|---|---|---|---|---|---|---|---|---|
| 03 | 23.04.2024 | Review | AA | DW | DW | | | |
| 02 | 18.03.2024 | Review | AA | DW | DW | | | |
| 01 | 12.02.2024 | Review | AA | DW | DW | | | |
| 00 | 25 12..2023 | Review | AA | DW | DW | | | |
| | | | Disc. Eng. | Disc. Lead | Contr. Rep | Disc. Eng. | Proj. Eng | Com.Rep. Dept. Head |

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| | **Category** | **Code** | **Description** |
| | Facility Area Code | 1P25A | **Numaligarh Refinery Expansion Project** |
| NRL's PO No. to tkIS: | Document Type | **PRC** | **PROCEDURE** |
| NRL's PO No. to Vendor / Contractor: PUR-PRJNUM-1004963/LOA/FABTECH | System Number | **00** | **General** |
| Vendor / Contractor Document N0.: FPRO-528-DC-1P25-CC-3128-001 | Life Cycle | | Disk Ref.: |

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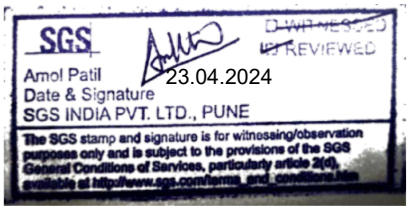
# PROCEDURE FOR POST WELD HEAT TREATMENT

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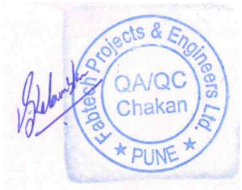
|  |  |  |

## 1.0 SCOPE

This procedure covers in detail method used for heat treatment (Post Weld & Post forming) and operational requirements to be followed for Columns & Dish ends there of constructed to ASME Section VIII Division 1 Edition 2021.

## 2.0 APPLICABLE CODE

- ASME Section VIII Division 1 Edition 2021
- Approved Drawing.
- General specification : NR-0ZZZZ-ME-SPE-0026, Rev-D1.
- Tag. No:- 1P25-CC-3127

## 3.0 RESPONSIBILITIES

QC Manager shall be responsible for approval of heat treatment procedure.
QC Manager is responsible for the evaluation of subcontractor including verification of calibration of temperature measuring and recording devices.
QC Manager is responsible for approval of thermal cycle for each heat treatment and for monitoring of heat treatment operations. He also checks the identification of items before sending for heat treatment and after receiving from heat treatment.

## 4.0 Fabrication Methodology of Column Shell Column will be formed in six sections.

Shell 1 to 5-Dish end + Skirt (15.5 M)- Weight- 107 MT
Shell 6 to 11 (18.0 M)- Weight-114 MT
Shell 12 to 18 (18.1 M) – Weight- 104 MT
Shell 19 to 24 (16.4M) – Weight – 94 MT
Shell 25 to 30 (16.5 M) - Weight- 94 MT
Shell 31-33 – Weight- 52 MT

## 5.0 METHODS OF HEAT TREATMENT

- Post weld heat treatment shall be carried out by the following methods.

| | | |
|---|---|---|
| a | Section-I (Shell 1 to 5 assembly & Dished end) | PWHT by Internal Oil firing Method |
| b | Section-II (Shell 6 to 11 assembly) | PWHT by Internal Oil firing Method |
| c | Section-III (Shell 12 to 18 assembly) | PWHT by Internal Oil firing Method |
| d | Section-IV (Shell 19 to 24 assembly) | PWHT by Internal Oil firing Method |
| e | Section-V (Sell 25 to 30 assembly) | PWHT by Internal Oil firing Method |
| f | Section -VI (Shell 31 to 33 assembly & Dished end) | PWHT by Internal Oil firing Method |
| g | Section-I to Section-II (Shell sec 5 + shell sec 6) | Local SR by electrical resistance coil method |
| h | Section-II to Section-III(Shell sec 11 + shell sec 12) | Local SR by electrical resistance coil method |
| i | Section-III to Section-IV(Shell sec 18 + shell sec 19) | Local SR by electrical resistance coil method |
| j | Section-IV to Section-V(Shell sec 24 + shell sec 25) | Local SR by electrical resistance coil method |
| k | Section-V to Section-VI(Shell sec 30 + shell sec 31) | Local SR by electrical resistance coil method |

- Surface of the components subjected to heat treatment shall be dry & free of any trace of oil , grease , threaded lubricants & paints
- The High velocity burner system in addition to being employed in a variety of furnace applications is widely utilized for heat treating large site columns on site. The application of exterior insulation means that the column in effect becomes a self-contained furnace fired by one or more number of high velocity burner
- This method utilizes convective heat which is most effective means of heat transfer below the radiant temperature .This results in fuel and time saving particularly in post weld heat treatment applications which demand a rapid turndown at the same time in a close tolerance. The above burner is fitted with direct Spark ignition system and flame failure detector to give complete safety to the process

**6.0 Insulation**

- The Exterior of the column shall be lagged over the entire surface with one layer of 100 mm to 150 mm thick high quality mineral wool or 50 mm thick ceramic wool to avoid any harmful thermal gradient and heat losses
- The insulation material shall be fitted with a meshed backing of non-galvanized iron wire. This Backing will serve to reinforce insulation and assist in shortening the work period involved for its application. Prior to heat treatment all gap in the insulation shall be plugged with loose insulations

**7.0 HEATING CONTROL**

The operation of Post Weld heat treatment & post forming heat treatment shall be carried out by the method given in 4.0 above in accordance with the following requirements:

**7.1** Thermal insulation wrapping from Outside will have Self-contained furnace . Distributor headers will be used for avoiding direct impingement of flames

**7.2** As per UW40 :-Heating the vessel internally by any appropriate means and with adequate indicating and recording temperature devices to aid in the control and maintenance of a uniform distribution of temperature in the vessel wall. Previous to this operation, the vessel should be fully enclosed with insulating material, or the permanent insulation may be installed provided it is suitable for the required temperature. In this procedure the internal pressure should be kept as low as practicable, but shall not exceed 50% of the maximum allowable working pressure at the highest metal temperature expected during the post weld heat treatment period.

**7.3** Distribution headers shall be further elevated towards the vessel CL as much as possible. Distributor headers will be used for avoiding direct impingement of flames

7.4 The burner are controlled by control panel incorporates oil & compressor air valves, oil solenoid valve, pressure gauge, flame failure device required for controlling the burners. The high velocity combustion fan completes the system oil pumping unit is supplied separately. This burner shall be controlled manually adjusting the oil flow.
To adjust back pressure exhaust shall be provided with butterfly valve. Inside environment of the furnace shall be so controlled as to avoid excess oxidation of surface of vessel.

7.5 The burner is designed to give a maximum flame length of approximately 12 inches (300mm) and shall be located away from the entry nozzle ( max. possible distance) hence only hot gases reach the shell of vessel and flame shall not direct impingement over the vessel surface. The turnaround ratio is extremely high-in order of 20.1 and gives a high degree of control at all stages of the firing. By this system no local hot spots are introduced and optimum temperature uniformity is achieved. There shall be no direct impingement of flame on the vessel or component . The burner shall be controlled manually by continual inspection of the temperature recording instrument. The hot gases emitting from the burner reach an exit velocity of 450 ft/appropriate per second (150 meter per second), consequently flame impingement is eliminated. The high speed of these gases produce 'scrubbing' action on vessel walls, with such positively induced convective heat transfer , by which close temperature uniformity and the flue to load temp. differential are greatly reduced. This results in both fuel and time saving particularly in PWHT applications which demands rapid turn around and at the same time, a close tolerance.

7.6 Back up calculations for rate of heating, soaking period & rate of cooling.

Governing Thk. Of vessel :- 56mm.

As per ASME Sec VIII Div. 1 (UCS 56)- Time required for heating of whole vessel must be 1 Hr/Inch :- Required heating/soaking time for whole vessel will be 132 Minutes (Min) but we are doing it 100 Minutes.

As per ASME Sec VIII Div. 1 - Rate of Heating must be 222 deg cel. divided by governing thickness in inches :- 222/2021 = 100.45 deg cel. Max = But we are doing heating at the rate of 120 deg cel. by considering vessel size.

As per ASME Sec VIII Div. 1 - Rate of cooling must be 280 deg cel. divided by governing thickness in inches :- 280/2.21 = 126.69 degree cel. Max = But we are doing cooling at the rate of 120 deg cel. by considering vessel size.

**7.8** Above 410°C, the rate of heating shall be not greater than 222°C/hr divided by the maximum metal thickness of the shell or head plate in inches, but in no case more than 120°C/hr.

**7.9** Above 410°C, cooling shall be done in a closed furnace (or) cooling chamber at a rate not greater than 280°C/hr divided by the maximum metal thickness of the shell /head plate in

inches, but in no case more than 120°C/hr. From 410°C the vessel may be cooled in still air.

**7.5** During the heating period there shall not be a greater variation in temperature throughout the portion of the Vessel being heated than 250°F (140°C) within any 15ft (4.6 m) interval.

**7.6** Vessels shall be held at or above the soaking time as per the approved thermal cycle. During the holding period, there shall not be a greater difference than 150°F (83°C) between the highest and lowest temperature throughout the portion of the dish end being heated, except where the range is further limited in the approved thermal cycle.

**7.7** Sufficient thermocouples shall be installed to assure control of the heat treatment temperature to ± 14° C during heating rate, cooling rate and holding time. As a minimum, thermocouples shall be required on both the inside and outside surfaces and at all changes in section.

**7.8** Continuous time-temperature records shall be obtained for all thermocouples to document that heat treatment.

**7.9** The maximum through thickness differential temperature shall not exceed 56° C at temperatures hotter than 410° C.

## 8.0 HEAT TREATMENT THERMAL CYCLE

A heat treatment Requisition cum Report prepared by Production Engineer & approved by QC Manager is supplied to the subcontractor along with relevant heat treatment procedure. This sheet indicates the thermal cycle heating / cooling rates, soaking time and temperature, thermocouple locations and placement, method of thermocouple attachment, maximum loading temperature, minimum unloading temperature, type of furnace, full / partial / local heat treatment, heating band width and Insulation requirement for local heat treatment, etc.

## 9.0 THERMOCOUPLE ATTACHMENT

Following procedure shall be followed

**9.1 Refer attached Annexure-I**

a) Thermocouple shall be attached to vessels & dish ends being heat treated by welding or tacking matching welding electrode of 5 mm dia. (after flux removal)
b) Make necessary clamping arrangement by welding nut to this welding electrode.
c) Hold thermocouple junction between above nut and bolt as shown in attached Sketch.
d) After completion of PWHT, remove welding electrode welded to job/component by smooth grinding followed by visual examination and PT/MT, as applicable.
e) Thermocouples shall be placed such that the entire component (including the anticipated hottest and coldest zones) is covered. All nozzles/extended parts/lifting trunnion's must be wrapped with electrical heating coils and must be monitored

with thermocouple arrangement at farthest Internal parts i.e., at the flange of the T-stiffeners, etc., to ensure uniform soaking time during Internal oil firing heat treatment.

f) The maximum distance between any two thermocouples shall not exceed 4.6 meters in any direction.

**OR**

**9.2** Capacitor discharge or electric resistance welding may be used for attaching bare-wire thermocouples, without subsequent post weld heat treatment, provided the energy output for welding is limited to 125 W-sec max. and any requirements specified in the applicable notes as found in tables UCS-56-1 through UCS-56-11 of ASME sec. VIII Div.1 shall apply. A welding procedure specification shall be prepared, and the content shall describe, as a minimum, the capacitor discharge equipment, the combinations of materials to be joined, and the technique of application. Qualification of the welding procedure is not required.

## 10.0 PWHT PROCEDURE

- Thermocouples will be located circumferentially and radially maximum up to 4.5m as per code of requirement & staggered
- The combustion equipment will comprise of burner, pilot burner with spark ignition systems, flexible hoses and control station .The fuel used for firing shall have low Sulphur content.
- Heat cycle profile control will be achieved by controlling fuel flow and combustion airflow through regulating valves
- During PWHT, Columns shall be blocked and supported as necessary to avoid deformation or damage
- Lead or Sulphur containing substances such as oil, grease, thread lubricants and paint shall be removed from column surfaces prior to heat treatment
- Any internal Parts installed in the Column prior to Heat treatment shall be assessed to ensure that their corrosion or material properties are not affected, and that their thermal expansion will not negatively affect the free thermal expansion of column

## 11.0 INSPECTION

QC Manager shall verify the following as per Heat treatment Requisition cum Report:

a) Thermocouple placement: A sketch showing the number and location details of thermocouples shall be maintained.

b) Supporting arrangement. On completion of heat treatment, QC Manager shall check the heat treatment chart for compliance to the recommended cycle and sign and date the chart if acceptable.

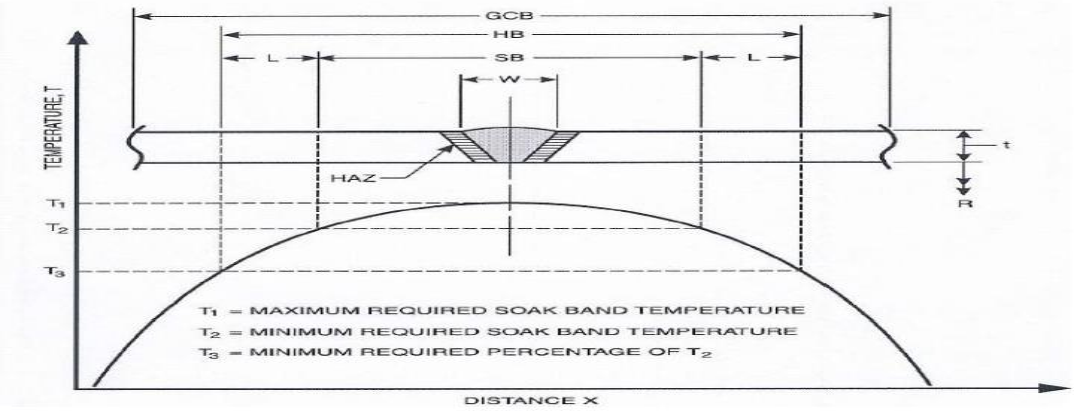
## 12.0 HEAT TREATMENT RECORDS

- Heat Treatment Chart
- Heat Treatment Requisition cum Report
- Calibration record of temperature measuring and recording devices.

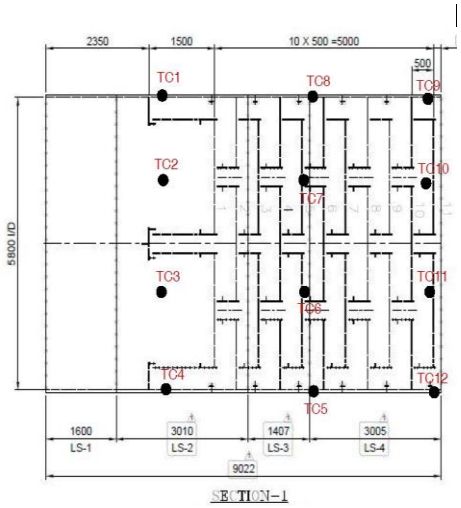
## 12.0 SAFETY

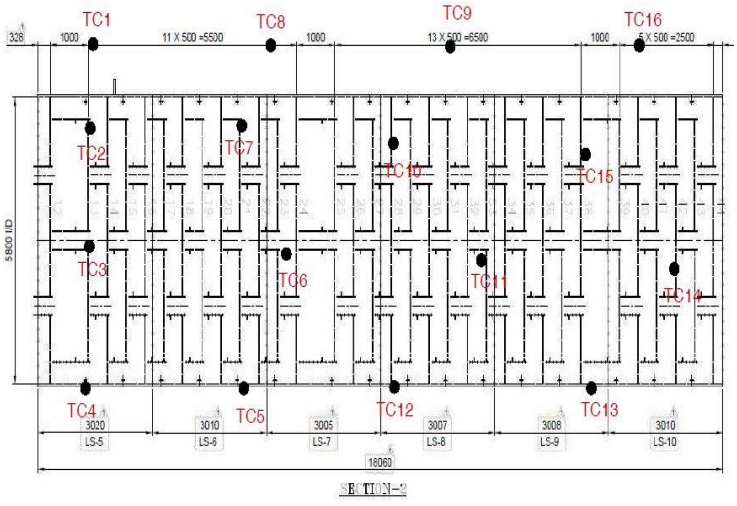
- The engineer will be designated as the safety officer in site to ensure that all operations are carried out in accordance with accepted safe working practice .He will be responsible to ensure that all safety requirements are fully complied

## 13.0 TYPICAL SKETCH FOR HEAT BAND & SOAK BAND




- **FOR EXAMPLE TYPICAL SKETCH OF THERMOCOUPLES ATTACHMENT ON VESSEL SECTION.**



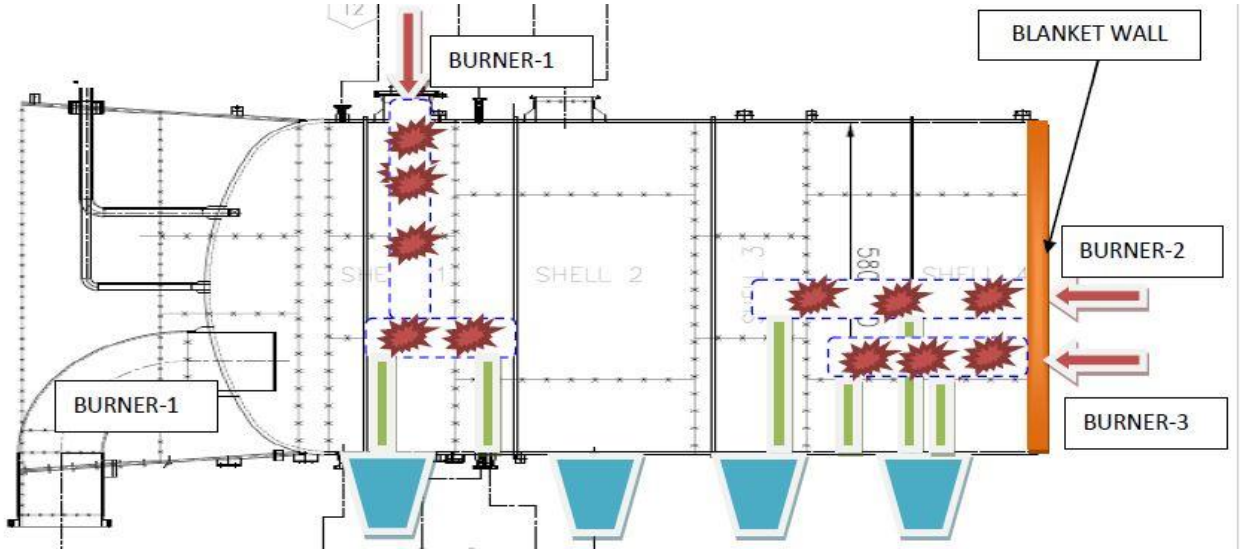




**Note:- The maximum distance between any two thermocouples shall not exceed 4.6 metres in any direction**

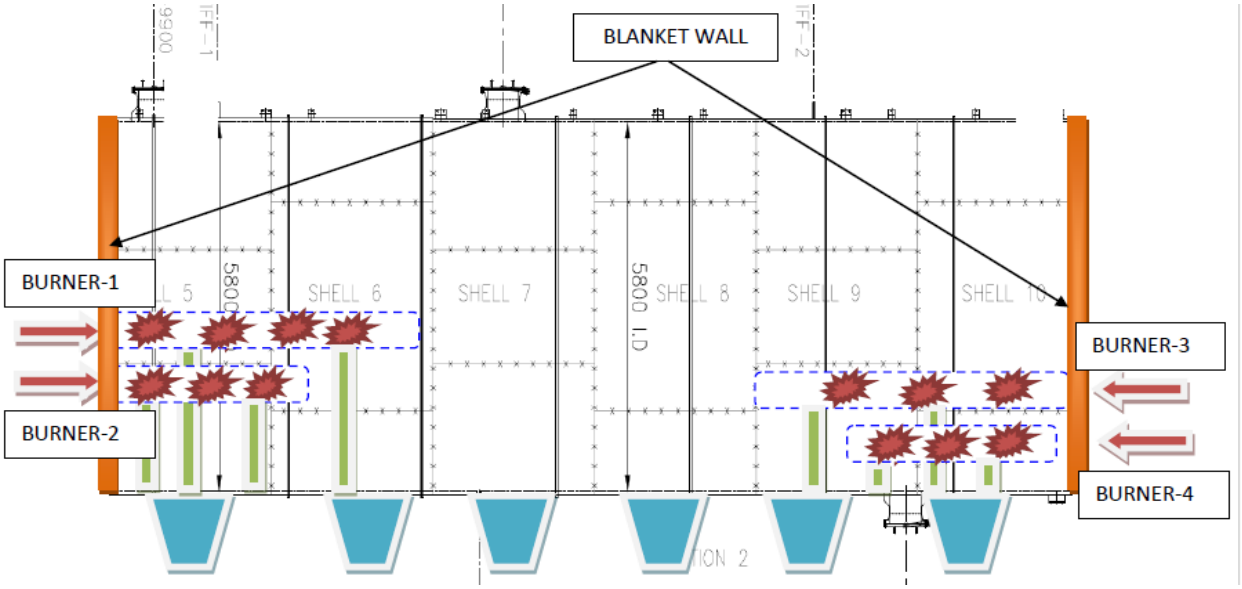
- Supporting Calculation for thermocouple attachment for Eg. Section 1:-

  Shell OD :- 5890 mm
  Shell OCF: 5890 x 3.142 = 18506.38
  Number of Thermocouple's required on OCF:- 18506.38/4500 = 4 Nos
  Number of Thermocouple's required on overall shell length :- 11000 / 4500 = 3
  Total No. of thermocouple required : 12 Nos.

- **Schematic view of burner attachment.**
- **Section 1**




- **Section 2**




- **For details of all the section's please find attached heat calculation sheet .**

## 15.0 HEAT TREATMENT CYCLE :- STRESS RELIVING

**FOR TAG : 1P25-CC-3127**

| | |
|---|---|
| Loading Temperature | $410^0$C (Max) |
| Heating rate above $410^0$C | $120^0$C/hr (Max) |
| Soaking Temperature | 621 $\pm10^0$C (Max) |
| Soaking time | 1 Hr. 40 minutes (min) |
| Rate of cooling up to $410^0$C | $120^0$C/hr |
| Unloading Temperature | $410^0$C/hr/ In still Air |

**Normalizing for Top & Bottom dish end.**

| | |
|---|---|
| Loading Temperature | $200^0$C (Max) |
| Heating rate above $410^0$C | $80^0$C/hr (Max) |
| Soaking Temperature | 920 $\pm10^0$C (Max) |
| Soaking time | 1 Hr. 05 minutes (min) |
| Rate of cooling | In still Air |

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# HEAT CALCULATION SHEET

## Heat Calculation (3127)

| | | |
|---|---|---|
| Job No. | : | **3127-SECTION-1** |
| Job description | : | C3 SPLITTER |
| Project | : | NREP – NUMALIGARH REFINERY EXPANSION PROJECT |
| Gross weight | : | 102220Kg |
| Material | : | CS |
| Density of insulating Blanket | : | 128 kg/ $m^3$ |
| Thickness of blanket | : | 0.050 m |
| Atmospheric temp. | : | $40^0$C (assumed) |
| Max temp. to be raised | : | $648^0$C |

| | | | |
|---|---|---|---|
| **1.0** | **Vessel Specification** | Vessel Mass<br>**102220 Kg (m)** | |
| **2.0** | **Thermal Properties** | Initial Temperature ($T_1$): $40^0$C<br>Soak Temp ($T_2$): $630^0$C<br>Specific Heat (c): 600 J/Kg.K | |
| **3.0** | **Energy Required to Heat Vessel** | **$Q=mc(T_2-T_1)$**<br>= Weight X sp. Heat X (648 – 40)<br>= 102220 X 600 X 608<br>= 37289856000 J = 37.28 GJ = 10355.55 kWh<br>Time to Temperature 10 hours<br>10355.55 /10= 1035.55 kW | **A1 = 1035.5 kW** |
| **4.0** | **Energy to raise Job insulation** | Job size : 11.3X5.8X5.8<br>Job area: 380.1 $m^2$<br>Specific Heat (c): 1050 J/Kg.k<br>Insulation Thickness: 50mm<br>Insulation Density: 128 kg/ $m^3$<br>Average Temperature: $325^0$C<br>Energy required: **$Q=mc(T_2-T_1)$**<br>**= 102220X1050X325=34882575000J=9689.60 kWh**<br>Time to Temperature 10 hours<br>9689.60 / 10= 968.9kW<br>**Job wt. = 102220Kg** | **A2 = 968.9 kW** |
| **5.0** | **Job Heat Losses** | Total Surface area: 380.1 $m^2$<br>Based on 50 thk, estimated heat loss<br>0.75kW/ $m^2$ | **A3=506.8 kW** |

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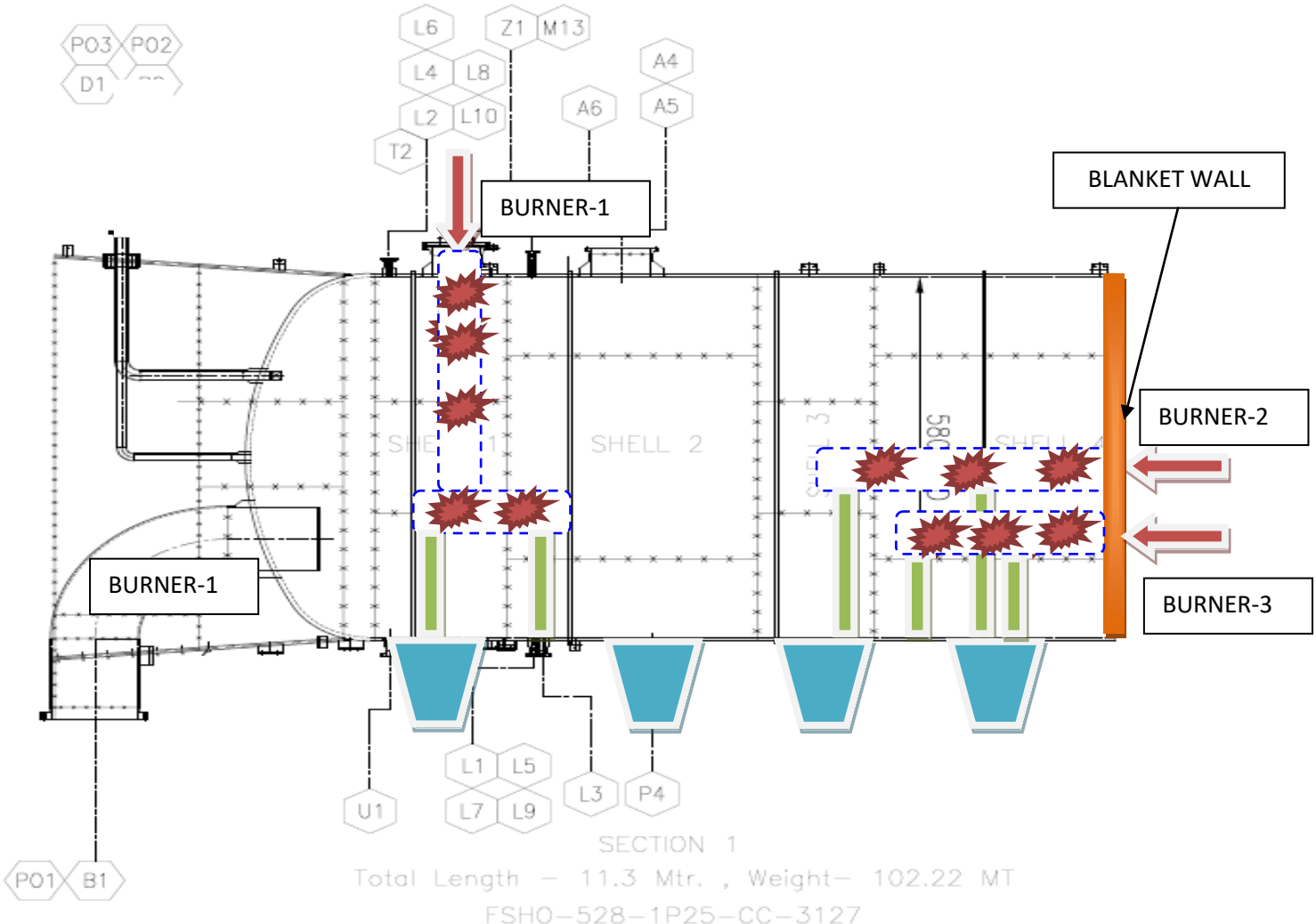
# HEAT CALCULATION SHEET

| | | | |
|---|---|---|---|
| | | **Total power required** | **A=2511.2 kW (A1+A2+A3)** |
| **6.0** | **Burner Properties** | Number of burners 3<br>Single burner rating 6 MBTU = 1758.42 kwh<br>Power available 5275.26 kWh with 3 Burners<br>Flue/Gas losses 40%<br>Net Power Available 5275.26 kWh | Power Available with Three 6 MBTU burner is **3165.16 kWh** |
| **7.0** | **Conclusion:**<br>Therefore, three burners having heat rating of 6 MBTU is enough to execute the heat treatment of above job. | | |



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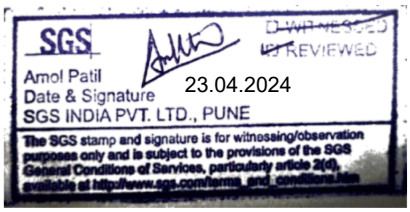
# HEAT CALCULATION SHEET

| | |
|---|---|
| BURNER-1 DISTRIBUTION PIPE LENGHTH | 3.5 & 1.5 METERS DIA 12” |
| BURNER-2 DISTRIBUTION PIPE LENGHTH | 5.5 METERS DIA 12” |
| BURNER-3 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12” |
| NOTE: COOL AIR SHALL BE TAKEN OUT FROM THE AVAILABLE NOZZLES PLEASE REFER DRAWING ABOVE | |

| | Prepared By | Checked/Approved By |
|---|---|---|
| **Name** | **Sadre Alam** | **Vinayak Jadhav** |
| **Signature** |  |  |
| **Date** | **11.04.2024** | **11.04.2024** |



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# HEAT CALCULATION SHEET

## Heat Calculation (3127)

| | | |
|---|---|---|
| Job No. | : | **3127-SECTION-2** |
| Job description | : | C3 SPLITTER |
| Project | : | NREP – NUMALIGARH REFINERY EXPANSION PROJECT |
| Gross weight | : | 119000Kg |
| Material | : | CS |
| Density of insulating Blanket | : | 128 kg/ $m^3$ |
| Thickness of blanket | : | 0.050 m |
| Atmospheric temp. | : | $40^0$C (assumed) |
| Max temp. to be raised | : | $648^0$C |

| | | | |
|---|---|---|---|
| **1.0** | **Vessel Specification** | Vessel Mass<br>**119000 Kg (m)** | |
| **2.0** | **Thermal Properties** | Initial Temperature ($T_1$): $40^0$C<br>Soak Temp ($T_2$): $630^0$C<br>Specific Heat (c): 600 J/Kg.K | |
| **3.0** | **Energy Required to Heat Vessel** | **$Q=mc(T_2-T_1)$**<br>= Weight X sp. Heat X (648 – 40)<br>= 119000 X 600 X 608<br>= 43411200000 J = 43.41 GJ = 12030.55 kWh<br>Time to Temperature 10 hours<br>12030.55 /10= 1203.0 kW | **A1 = 1203 kW** |
| **4.0** | **Energy to raise Job insulation** | Job size : 18X5.8X5.8<br>Job area: 605.52 $m^2$<br>Specific Heat (c): 1050 J/Kg.k<br>Insulation Thickness: 50mm<br>Insulation Density: 128 kg/ $m^3$<br>Average Temperature: $325^0$C<br>Energy required: **$Q=mc(T_2-T_1)$**<br>**= 119000X1050X325=40608750000J=11280.2 kWh**<br>Time to Temperature 10 hours<br>11280.2 / 10= 1128.0kW<br>**Job wt. = 119000Kg** | **A2 = 1128.0 kW** |
| **5.0** | **Job Heat Losses** | Total Surface area: 605.52 $m^2$<br>Based on 50 thk, estimated heat loss<br>0.75kW/ $m^2$ | **A3=807.36 kW** |

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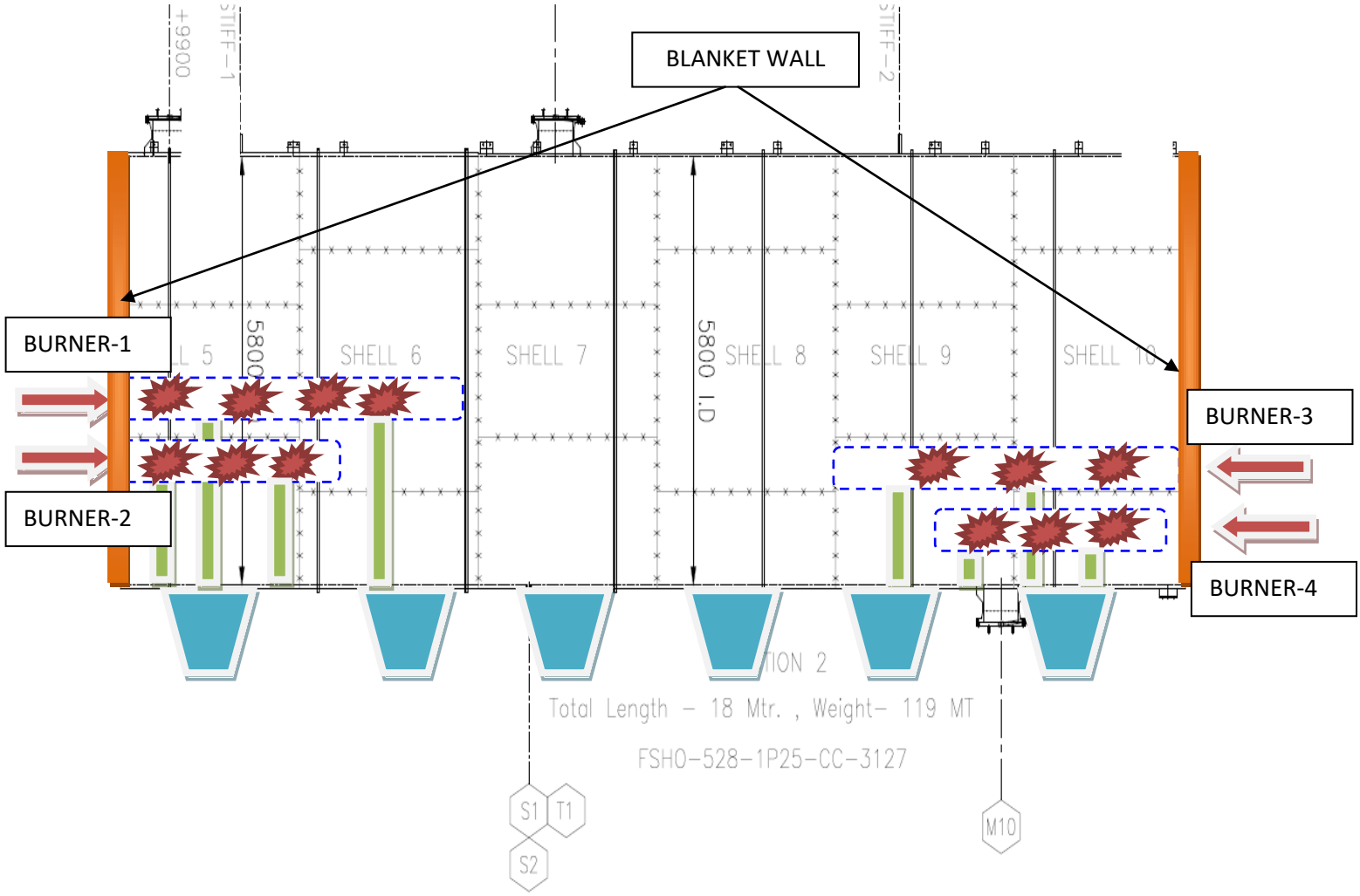
# HEAT CALCULATION SHEET

| | | | |
|---|---|---|---|
| | | **Total power required** | **A=3138.36 kW (A1+A2+A3)** |
| **6.0** | **Burner Properties** | Number of burners 4<br>Single burner rating 6 MBTU = 1758.42 kwh<br>Power available 7033.68 kWh with 3 Burners<br>Flue/Gas losses 40%<br>Net Power Available 7033.68 kWh | Power Available with Four 6 MBTU burner is **4220.20 kWh** |
| **7.0** | **Conclusion:**<br>Therefore, four burners having heat rating of 6 MBTU is enough to execute the heat treatment of above job. | | |



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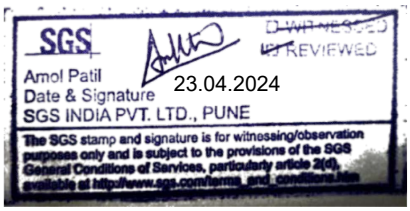
# HEAT CALCULATION SHEET

| | |
|---|---|
| BURNER-1 DISTRIBUTION PIPE LENGHTH | 7 METERS DIA 12” |
| BURNER-2 DISTRIBUTION PIPE LENGHTH | 3.5 METERS DIA 12” |
| BURNER-3 DISTRIBUTION PIPE LENGHTH | 7 METERS DIA 12” |
| BURNER-4 DISTRIBUTION PIPE LENGHTH | 3.5 METERS DIA 12” |
| NOTE: COOL AIR SHALL BE TAKEN OUT FROM THE AVAILABLE NOZZLES PLEASE REFER DRAWING ABOVE | |

| | Prepared By | Checked/Approved By |
|---|---|---|
| **Name** | **Sadre Alam** | **Vinayak Jadhav** |
| **Signature** |  |  |
| **Date** | **11.04.2024** | **11.04.2024** |



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# HEAT CALCULATION SHEET

## Heat Calculation (3127)

| | | |
|---|---|---|
| Job No. | : | **3127-SECTION-3** |
| Job description | : | C3 SPLITTER |
| Project | : | NREP – NUMALIGARH REFINERY EXPANSION PROJECT |
| Gross weight | : | 95000Kg |
| Material | : | CS |
| Density of insulating Blanket | : | 128 kg/ $m^3$ |
| Thickness of blanket | : | 0.050 m |
| Atmospheric temp. | : | $40^0$C (assumed) |
| Max temp. to be raised | : | $648^0$C |

| | | | |
|---|---|---|---|
| **1.0** | **Vessel Specification** | Vessel Mass<br>**95000 Kg (m)** | |
| **2.0** | **Thermal Properties** | Initial Temperature ($T_1$): $40^0$C<br>Soak Temp ($T_2$): $630^0$C<br>Specific Heat (c): 600 J/Kg.K | |
| **3.0** | **Energy Required to Heat Vessel** | **$Q=mc(T_2-T_1)$**<br>= Weight X sp. Heat X (648 – 40)<br>= 95000 X 600 X 608<br>= 34656000000 J = 34.65 GJ = 9625 kWh<br>Time to Temperature 10 hours<br>9625 /10= 962.5 kW | **A1 = 962.5 kW** |
| **4.0** | **Energy to raise Job insulation** | Job size : 16.5X5.8X5.8<br>Job area: 555.06 $m^2$<br>Specific Heat (c): 1050 J/Kg.k<br>Insulation Thickness: 50mm<br>Insulation Density: 128 kg/ $m^3$<br>Average Temperature: $325^0$C<br>Energy required: **$Q=mc(T_2-T_1)$**<br>**= 950000X1050X325=32418750000J=9005.20 kWh**<br>Time to Temperature 10 hours<br>9005.20 / 10= 905.5 kW<br>**Job wt. = 95000Kg** | **A2 = 905.5 kW** |
| **5.0** | **Job Heat Losses** | Total Surface area: 555.06 $m^2$<br>Based on 50 thk, estimated heat loss<br>0.75kW/ $m^2$ | **A3=740.08 kW** |

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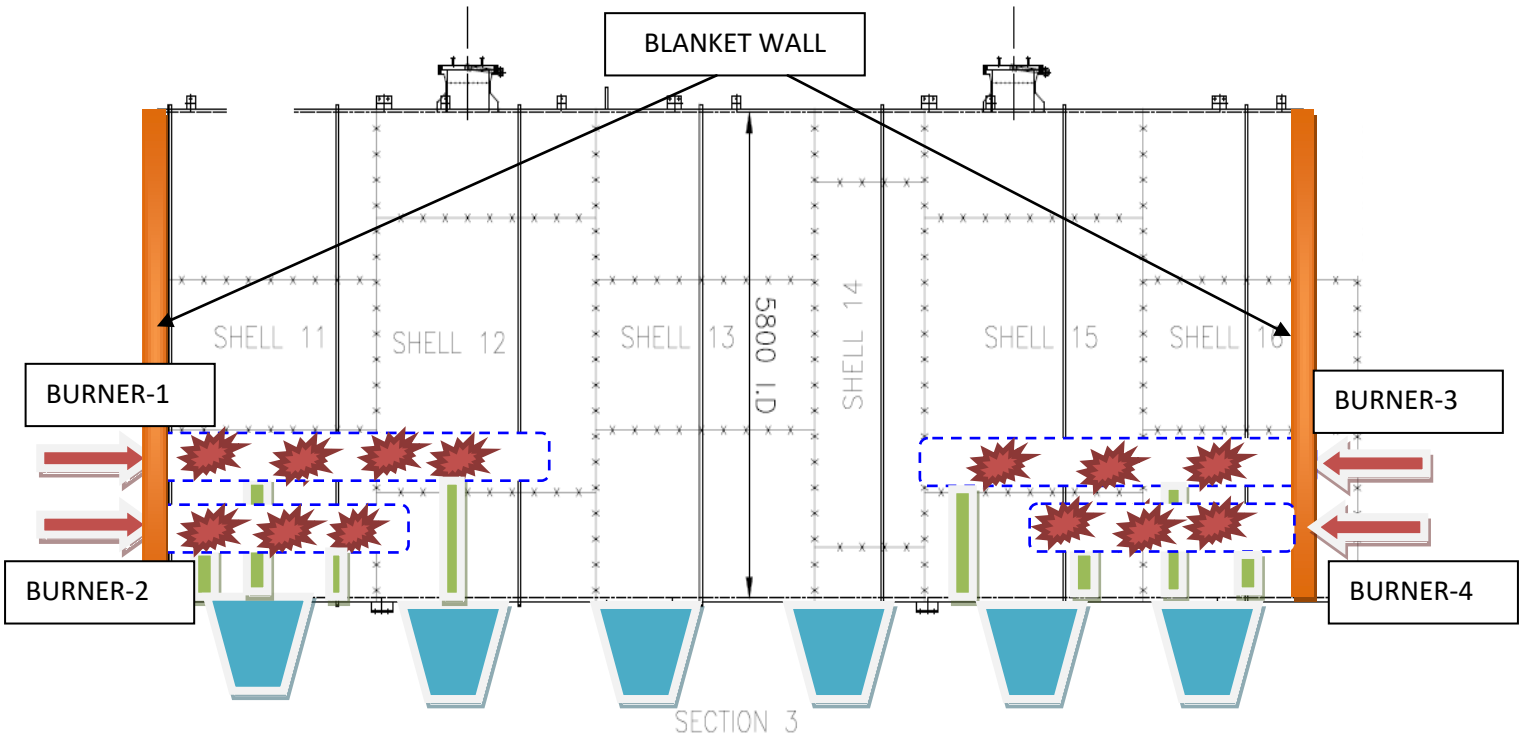
# HEAT CALCULATION SHEET

| | | | |
|---|---|---|---|
| | | **Total power required** | **A=2608.08 kW (A1+A2+A3)** |
| **6.0** | **Burner Properties** | Number of burners 4<br>Single burner rating 6 MBTU = 1758.42 kwh<br>Power available 7033.68 kWh with 3 Burners<br>Flue/Gas losses 40%<br>Net Power Available 7033.68 kWh | Power Available with Four 6 MBTU burner is **4220.20 kWh** |
| **7.0** | **Conclusion:**<br>Therefore, four burners having heat rating of 6 MBTU is enough to execute the heat treatment of above job. | | |



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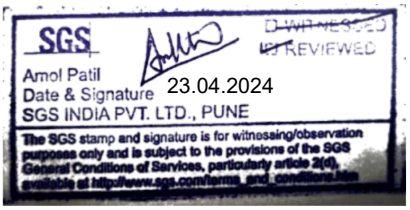
# HEAT CALCULATION SHEET

| | |
|---|---|
| BURNER-1 DISTRIBUTION PIPE LENGHTH | 5.5 METERS DIA 12” |
| BURNER-2 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12” |
| BURNER-3 DISTRIBUTION PIPE LENGHTH | 5.5 METERS DIA 12” |
| BURNER-4 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12” |
| NOTE: COOL AIR SHALL BE TAKEN OUT FROM THE AVAILABLE NOZZLES PLEASE REFER DRAWING ABOVE | |

| | Prepared By | Checked/Approved By |
|---|---|---|
| **Name** | **Sadre Alam** | **Vinayak Jadhav** |
| **Signature** |  |  |
| **Date** | **11.04.2024** | **11.04.2024** |



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# HEAT CALCULATION SHEET

## Heat Calculation (3127)

| | | |
|---|---|---|
| Job No. | : | **3127-SECTION-** |
| Job description | : | C3 SPLITTER |
| Project | : | NREP – NUMALIGARH REFINERY EXPANSION PROJECT |
| Gross weight | : | 86400Kg |
| Material | : | CS |
| Density of insulating Blanket | : | 128 kg/ $m^3$ |
| Thickness of blanket | : | 0.050 m |
| Atmospheric temp. | : | $40^0$C (assumed) |
| Max temp. to be raised | : | $648^0$C |

| | | | |
|---|---|---|---|
| **1.0** | **Vessel Specification** | Vessel Mass<br>**86400 Kg (m)** | |
| **2.0** | **Thermal Properties** | Initial Temperature ($T_1$): $40^0$C<br>Soak Temp ($T_2$): $630^0$C<br>Specific Heat (c): 600 J/Kg.K | |
| **3.0** | **Energy Required to Heat Vessel** | **$Q=mc(T_2-T_1)$**<br>= Weight X sp. Heat X (648 – 40)<br>= 86400 X 600 X 608<br>= 31518720000 J = 31.51 GJ = 8752.77 kWh<br>Time to Temperature 10 hours<br>8752.77 /10= 875.2 kW | **A1 = 875.2 kW** |
| **4.0** | **Energy to raise Job insulation** | Job size : 15X5.8X5.8<br>Job area: 504.6 $m^2$<br>Specific Heat (c): 1050 J/Kg.k<br>Insulation Thickness: 50mm<br>Insulation Density: 128 kg/ $m^3$<br>Average Temperature: $325^0$C<br>Energy required: **$Q=mc(T_2-T_1)$**<br>**= 864000X1050X325=29484000000J=8190 kWh**<br>Time to Temperature 10 hours<br>8190 / 10= 819.0 kW<br>**Job wt. = 84600Kg** | **A2 = 819.0 kW** |
| **5.0** | **Job Heat Losses** | Total Surface area: 504.6 $m^2$<br>Based on 50 thk, estimated heat loss<br>0.75kW/ $m^2$ | **A3=672.8 kW** |

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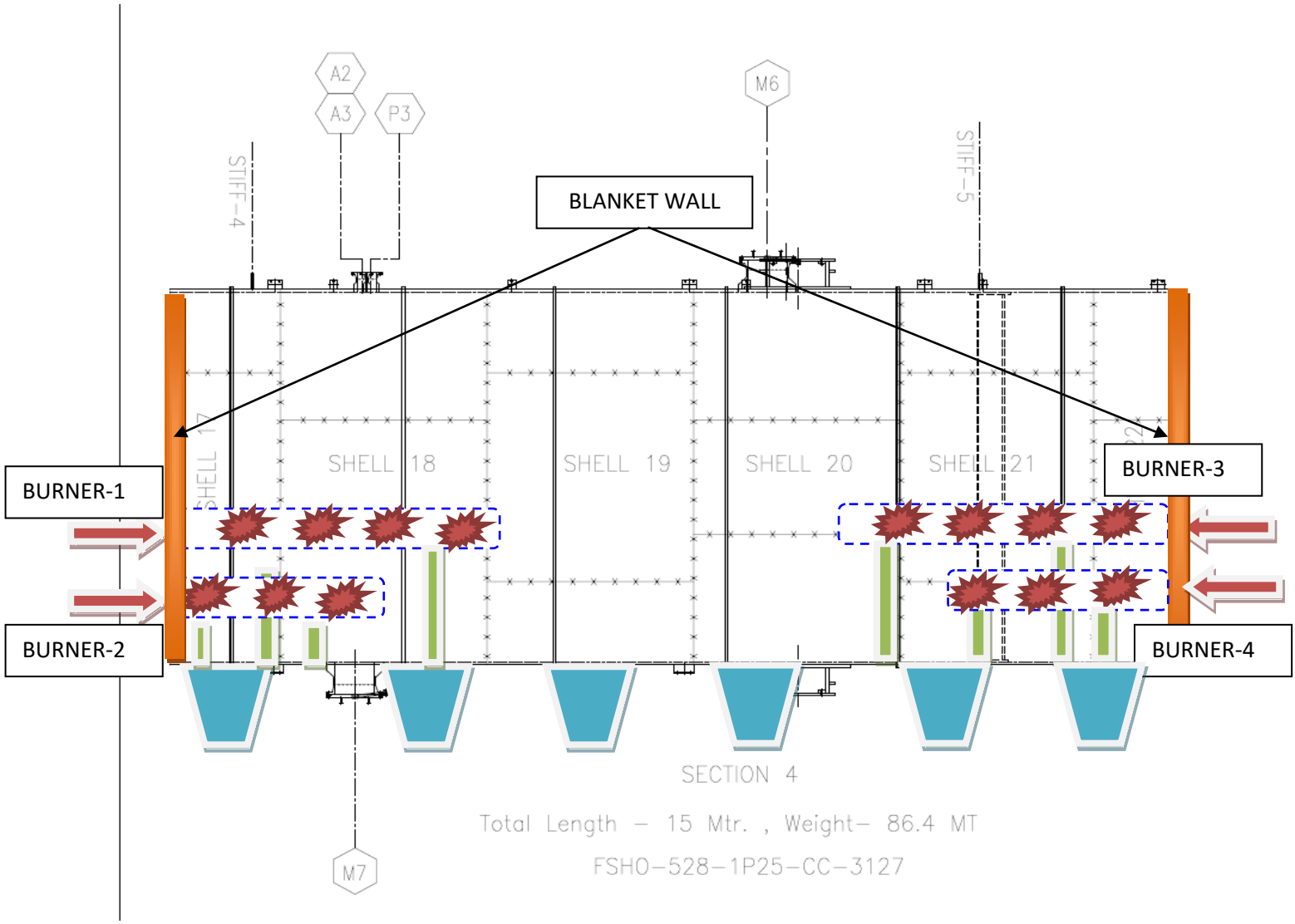
# HEAT CALCULATION SHEET

| | | | |
|---|---|---|---|
| | | **Total power required** | **A=2367 kW (A1+A2+A3)** |
| **6.0** | **Burner Properties** | Number of burners 4<br>Single burner rating 6 MBTU = 1758.42 kwh<br>Power available 7033.68 kWh with 3 Burners<br>Flue/Gas losses 40%<br>Net Power Available 7033.68 kWh | Power Available with Four 6 MBTU burner is **4220.20 kWh** |
| **7.0** | **Conclusion:**<br>Therefore, four burners having heat rating of 6 MBTU is enough to execute the heat treatment of above job. | | |



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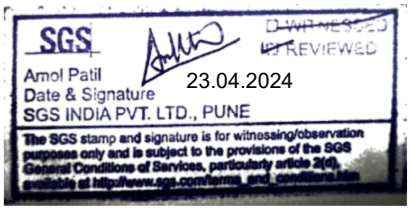
# HEAT CALCULATION SHEET

| | |
|---|---|
| BURNER-1 DISTRIBUTION PIPE LENGHTH | 5.5 METERS DIA 12" |
| BURNER-2 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12" |
| BURNER-3 DISTRIBUTION PIPE LENGHTH | 5.5 METERS DIA 12" |
| BURNER-4 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12" |
| NOTE: COOL AIR SHALL BE TAKEN OUT FROM THE AVAILABLE NOZZLES PLEASE REFER DRAWING ABOVE | |

| | Prepared By | Checked/Approved By |
|---|---|---|
| **Name** | **Sadre Alam** | **Vinayak Jadhav** |
| **Signature** |  |  |
| **Date** | **11.04.2024** | **11.04.2024** |



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# HEAT CALCULATION SHEET

## Heat Calculation (3127)

| | | |
|---|---|---|
| Job No. | : | **3127-SECTION-5** |
| Job description | : | C3 SPLITTER |
| Project | : | NREP – NUMALIGARH REFINERY EXPANSION PROJECT |
| Gross weight | : | 103700Kg |
| Material | : | CS |
| Density of insulating Blanket | : | 128 kg/ $m^3$ |
| Thickness of blanket | : | 0.050 m |
| Atmospheric temp. | : | $40^0$C (assumed) |
| Max temp. to be raised | : | $648^0$C |

| | | | |
|---|---|---|---|
| **1.0** | **Vessel Specification** | Vessel Mass<br>**103700 Kg (m)** | |
| **2.0** | **Thermal Properties** | Initial Temperature ($T_1$): $40^0$C<br>Soak Temp ($T_2$): $630^0$C<br>Specific Heat (c): 600 J/Kg.K | |
| **3.0** | **Energy Required to Heat Vessel** | **$Q=mc(T_2-T_1)$**<br>= Weight X sp. Heat X (648 – 40)<br>= 103700 X 600 X 608<br>= 37829760000 J = 37.82 GJ = 10505.55 kWh<br>Time to Temperature 10 hours<br>10505.55 /10= 1050.5 kW | **A1 = 1050.5 kW** |
| **4.0** | **Energy to raise Job insulation** | Job size : 16.5X5.8X5.8<br>Job area: 555.06 $m^2$<br>Specific Heat (c): 1050 J/Kg.k<br>Insulation Thickness: 50mm<br>Insulation Density: 128 kg/ $m^3$<br>Average Temperature: $325^0$C<br>Energy required: **$Q=mc(T_2-T_1)$**<br>**= 103700X1050X325=35387625000J=9829.89 kWh**<br>Time to Temperature 10 hours<br>9829.89 / 10= 982.9 kW<br>**Job wt. = 103700Kg** | **A2 = 982.9 kW** |
| **5.0** | **Job Heat Losses** | Total Surface area: 555.06 $m^2$<br>Based on 50 thk, estimated heat loss<br>0.75kW/ $m^2$ | **A3=740.08 kW** |

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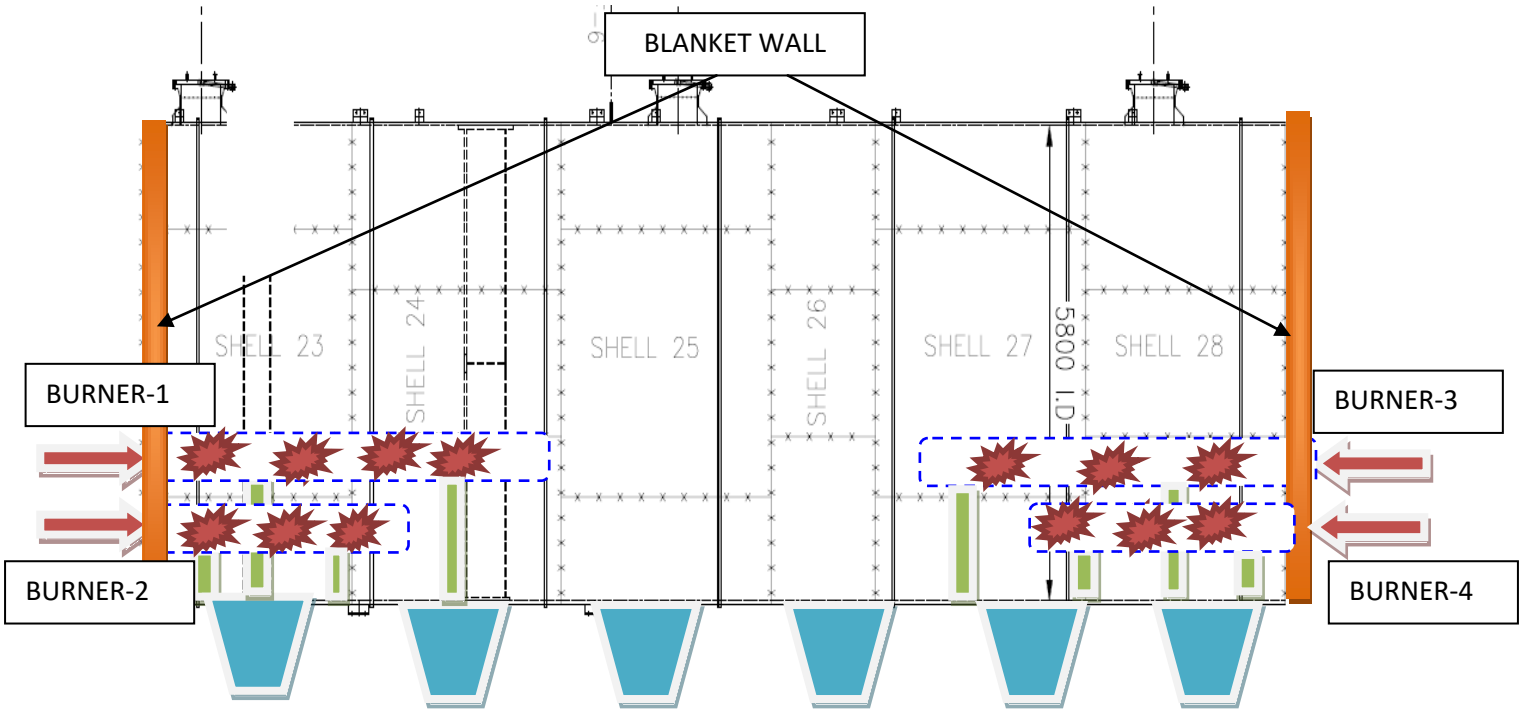
# HEAT CALCULATION SHEET

| | | | |
|---|---|---|---|
| | | **Total power required** | **A=2733.48 kW (A1+A2+A3)** |
| **6.0** | **Burner Properties** | Number of burners 4<br>Single burner rating 6 MBTU = 1758.42 kwh<br>Power available 7033.68 kWh with 3 Burners<br>Flue/Gas losses 40%<br>Net Power Available 7033.68 kWh | Power Available with Four 6 MBTU burner is **4220.20 kWh** |
| **7.0** | **Conclusion:**<br>Therefore, four burners having heat rating of 6 MBTU is enough to execute the heat treatment of above job. | | |



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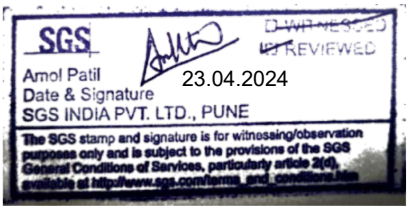
# HEAT CALCULATION SHEET

| | |
|---|---|
| BURNER-1 DISTRIBUTION PIPE LENGHTH | 5.5 METERS DIA 12” |
| BURNER-2 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12” |
| BURNER-3 DISTRIBUTION PIPE LENGHTH | 5.5 METERS DIA 12” |
| BURNER-4 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12” |
| NOTE: COOL AIR SHALL BE TAKEN OUT FROM THE AVAILABLE NOZZLES PLEASE REFER DRAWING ABOVE | |

| | Prepared By | Checked/Approved By |
|---|---|---|
| **Name** | **Sadre Alam** | **Vinayak Jadhav** |
| **Signature** |  |  |
| **Date** | **11.04.2024** | **11.04.2024** |



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# HEAT CALCULATION SHEET

## Heat Calculation (3127)

| | | |
|---|---|---|
| Job No. | : | **3127-SECTION-6** |
| Job description | : | C3 SPLITTER |
| Project | : | NREP – NUMALIGARH REFINERY EXPANSION PROJECT |
| Gross weight | : | 93600 Kg |
| Material | : | CS |
| Density of insulating Blanket | : | 128 kg/ $m^3$ |
| Thickness of blanket | : | 0.050 m |
| Atmospheric temp. | : | $40^0$C (assumed) |
| Max temp. to be raised | : | $648^0$C |

| | | | |
|---|---|---|---|
| **1.0** | **Vessel Specification** | Vessel Mass<br>**93600 Kg (m)** | |
| **2.0** | **Thermal Properties** | Initial Temperature ($T_1$): $40^0$C<br>Soak Temp ($T_2$): $630^0$C<br>Specific Heat (c): 600 J/Kg.K | |
| **3.0** | **Energy Required to Heat Vessel** | **$Q=mc(T_2-T_1)$**<br>= Weight X sp. Heat X (648 – 40)<br>= 93600 X 600 X 608<br>= 34145280,000 J = 34.14 GJ = 9483.33 kWh<br>Time to Temperature 10 hours<br>9483.33 /10= 948.3 kW | **A1 = 948.3 kW** |
| **4.0** | **Energy to raise Job insulation** | Job size : 15.43X5.8X5.8<br>Job area: 519.06 $m^2$<br>Specific Heat (c): 1050 J/Kg.k<br>Insulation Thickness: 50mm<br>Insulation Density: 128 kg/ $m^3$<br>Average Temperature: $325^0$C<br>Energy required: **$Q=mc(T_2-T_1)$**<br>**= 93600X1050X325=31941000000J=8872.5 kWh**<br>Time to Temperature 10 hours<br>8872.5 / 10= 887.2kW<br>**Job wt. = 93600Kg** | **A2 = 887.2 kW** |
| **5.0** | **Job Heat Losses** | Total Surface area: 519.06 $m^2$<br>Based on 50 thk, estimated heat loss<br>0.75kW/ $m^2$ | **A3=692.08 kW** |

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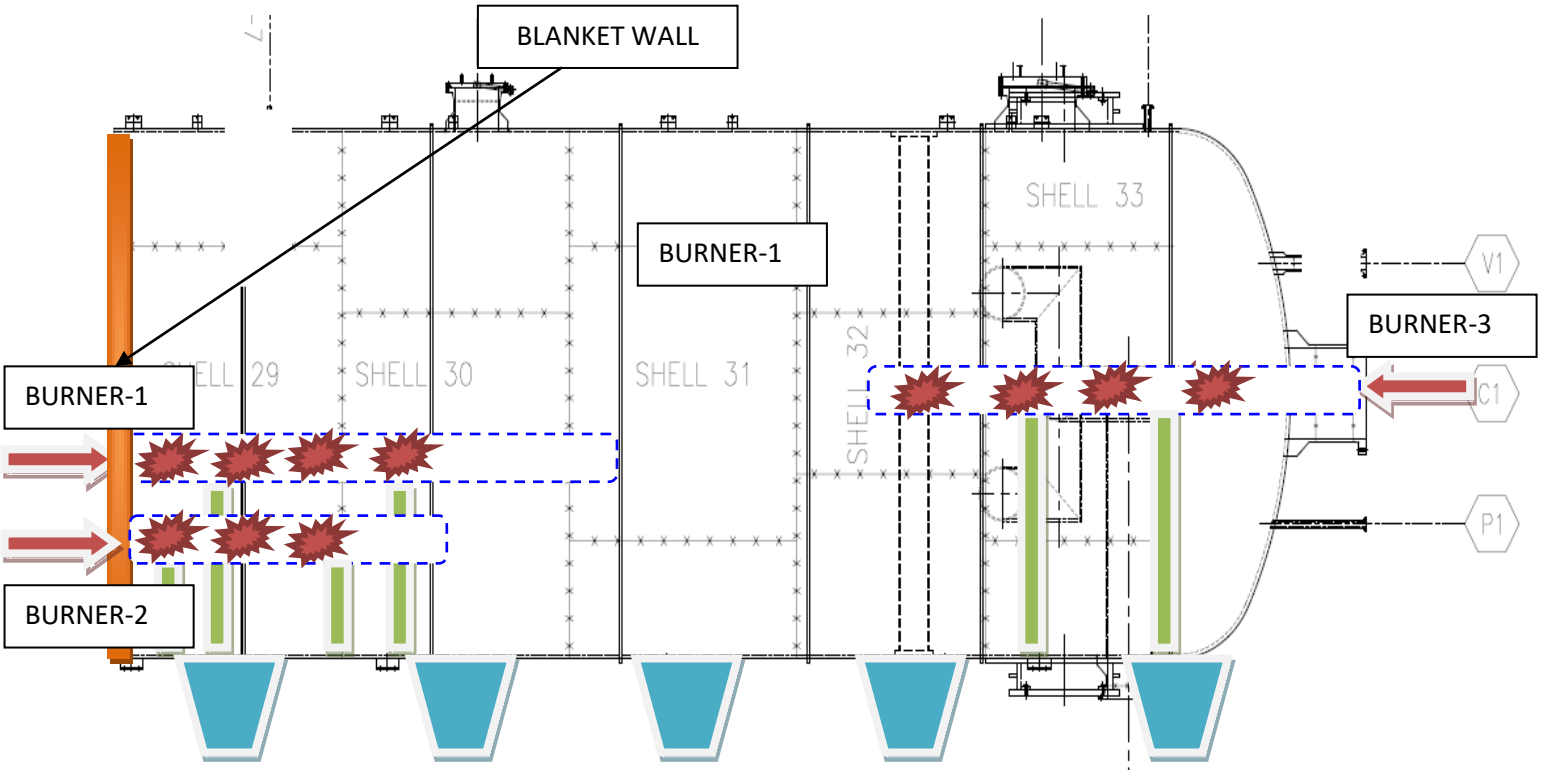
# HEAT CALCULATION SHEET

| | | | |
|---|---|---|---|
| | | **Total power required** | **A=2527.58 kW (A1+A2+A3)** |
| **6.0** | **Burner Properties** | Number of burners 3<br>Single burner rating 6 MBTU = 1758.42 kwh<br>Power available 5275.26 kWh with 3 Burners<br>Flue/Gas losses 40%<br>Net Power Available 5275.26 kWh | Power Available with Three 6 MBTU burner is **3165.16 kWh** |
| **7.0** | **Conclusion:**<br>Therefore, three burners having heat rating of 6 MBTU is enough to execute the heat treatment of above job. | | |



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# HEAT CALCULATION SHEET

| | |
|---|---|
| BURNER-1 DISTRIBUTION PIPE LENGHTH | 7.5 METERS DIA 12” |
| BURNER-2 DISTRIBUTION PIPE LENGHTH | 3 METERS DIA 12” |
| BURNER-3 DISTRIBUTION PIPE LENGHTH | 4 METERS DIA 12” |
| NOTE: COOL AIR SHALL BE TAKEN OUT FROM THE AVAILABLE NOZZLES PLEASE REFER DRAWING ABOVE | |

| | Prepared By | Checked/Approved By |
|---|---|---|
| **Name** | **Sadre Alam** | **Vinayak Jadhav** |
| **Signature** |  |  |
| **Date** | **11.04.2024** | **11.04.2024** |