# *Technical & Commercial Evaluation Of Steam Tracing System V/s SECT™ Skin Effect Heating System Electric Heat Tracing System*

**For**

**SUITED COSTAL / EXPORT REFINERY PROJECTS**

**5-Km 450 NB (18” Dia.) Long Pipe Line From SEZ Tank-farm to DTA Tank-farm for Maintaining Vacuum Residue (VR) Fluid at 200 deg.C,**

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# *Skin Effect Heating System Electric Heat Tracing SECT, System*

## Useful For Refinery Projects

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## TABLE OF CONTENT

**PAGE**

# 1.0 Introduction

## *General*

For High Temperature (200$^{O}$C or thereabout) long transfer lines carrying high viscosity and high pour point fluids such as Vacuum Residue, as a norm worldwide, uses Steam Tracing by and large, and Electric heat Tracing System where Steam is not available and/or it is difficult to carry at long distances. This Study presents economics of Skin Effect Electrical Tracing System (SECT), over the Steam Tracing option. This study presents the options for Coastal Refineries undergoing modernization and entering into export of High Pour Point and High Viscosity Fluids such as hot Vacuum Residue (VR)

Refineries have availability of High Pressure Steam at 42.2 kg/cm$^2$(g), the option of using steam tracing is primarily explored on the basis of perceived Reliability, and Technical & Economic consideration. For this, a selective study is prepared for the 5,000 M section running from Special Export Zone (SEZ) tank-farm to Duty Tariff Area (DTA) tank-farm, a line which will run outside of refinery battery limits and which has to cross below the railway tracks and road crossings, at several locations along the route. The Installation Cost and Energy Consumption cost for this section are summarized below.

## *Summary of Total Installed Cost (TIC) and Total Operating Cost (TOC) of Steam Tracing System and SECT Electric Heat Tracing System.*

## *Total Installed Cost (TIC)*

| STEAM TRACING<br>**Rs. Lacs** | **SECT ELECTRIC**<br>**Rs. Lacs** |
|---|---|
| **654** | **285**<br>(Add Cost of Power Cable to Transformers) |

## *Total Operating Cost (TOC)*

(8,000 operating hours /year)

| STEAM TRACING **Rs. Lacs/Year** | **SECT ELECTRIC Rs. Lacs/Year** |
|---|---|
| **658** | **112** |

[CONSULTANT Steam Cost Ref.: @ USD 15.8 per MT; and Power Cost @USD 67 MW]

## *Energy Consumption Rate*

(* At Annual mean average ambient temperature of 25$^{O}$C)

| STEAM TRACING **Kg. Steam / hour** | ***** SECT ELECTRIC **kWh** |
|---|---|
| **11,586** | **469** |

The Total Installed Cost (TIC) figures shown above are suggestive that the SECT Electric Tracing System will cost less than half the Steam Tracing Total Installed Cost.

Again, on the Total Operating Cost, the figures shown are suggestive that even if the installed cost for Steam Tracing System was Nil, the SECT Electric Tracing Cost would be recovered within the first year of operation, based on the Total Operating Cost Savings.

From the Energy angle, 11.586 MT of Steam from a Thermal Power Plant would generate 811 kWh of Power (@ 1 MT Steam generates 70kW); of which **70%,** i.e. 567.7 kWh would be generated in a Condensing Turbine cycle. Accordingly, there would be substantial savings in Power if SECT Electric Heat Tracing system is opted over Steam Tracing System.

Furthermore, it is increasingly being established worldwide to Electrically Heat Trace long transfer lines carrying High viscosity and High Pour Point fluids at around 200$^{O}$C.

For better understanding of the Steam Tracing System Design & Costs, the following section deals with the basic logical steps and criteria considered in arriving at these Total Cost concepts towards Installation and Operating aspects of the Two Heat Tracing Options, Steam and SECT Electric.

## 2.0 Total Installed Cost (TIC) of Steam Tracing System

The installation cost for Steam Tracing system for a 5,000 M 450NB (18" dia.) pipeline at maintain temperature of 200$^{O}$C, considers the costs towards:

a) Steam tracers along with its Steam Trap assemblies.
b) Steam Manifolds and steam supply connection from manifold to tracer inlet; and, Condensate discharge manifolds and connections from the tracer steam trap discharge to the condensate Manifold.
c) Steam Header, which runs parallel to VR pipeline, to feed steam supply for the steam tracing system along the 5,000 M run.
d) Steam Header to transport Steam from Refinery battery limit to the SEZ tank-farm at a distance of 2,500 M length at 42.2 Kg/cm$^2$(g)
e) Cost of Thermal bonding material, for the required heat output from steam tracers.

The standards and data considered for the above stated components of the steam tracing system are explained below.

### *2.1 Steam Tracers*

The standards / norms considered for steam tracer installation are:

a. Operating Steam Pressure of 42.2 Kg/cm$^2$(g) [by CONSULTANT]
b. Steam Tracer size 15NB carbon steel
c. Ratio of number of thermally BONDED Steam tracers to a unit meter length of 450 NB VR pipe is Six (6) [by CONSULTANT, as the best judgment, since the BARE steam tracers standards available were for maximum maintain temperature of around 149$^{O}$C only]
d. Steam Trapping distance interval at every 60 M [by CONSULTANT]
e. Cost of 15 NB tracer CS pipe at Rs.300/= per meter [by CONSULTANT]
f. Condensate to be discharged to open French Drains. Hence, no closed loop with a by-pass required for steam trap assembly.

Thus, the total requirement is of 30,000 M of 15 NB Steam tracers for a 5,000 M of 450NB (18" dia) VR pipe line.

### *2.2 Manifolds and Branch Connection Pipes*

a. Manifold of 40NB pipe to feed 12 nos. of steam tracing circuit is considered [handbook standards / industry practice]
b. Each Steam supply manifold will have a steam trap assembly.

c. Branch line connections from the steam manifold to steam tracer inlet; and branch connection from steam trap outlet to condensate manifold, each of which has been considered to be of 2 M.
d. Each manifold shall be at every 60 M interval.
e. Thermal insulation cost for the manifold and branch connecting pipes has been considered.

## *2.3 Steam Feeding Header*

a. Steam feeding header of 150NB (6"dia.) to carry estimated 11.5 MT steam per hour at 42.2 Kg/cm$^2$(g) has been considered and found suitable [by CONSULTANT
b. Steam feeding header shall also be drained every 6M [by CONSULTANT]
c. The condensate discharge from steam strap on steam header is considered to be led into a French Pit [by CONSULTANT]

## *2.4 Steam Transport Header*

The steam shall be transported from the Refinery battery limit to the SEZ tank farm.

a. Steam transport header of 150NB (6"dia.) to carry estimated 11.5 MT steam per hour at 42.2 Kg/cm$^2$(g) has been considered and found suitable [by CONSULTANT]

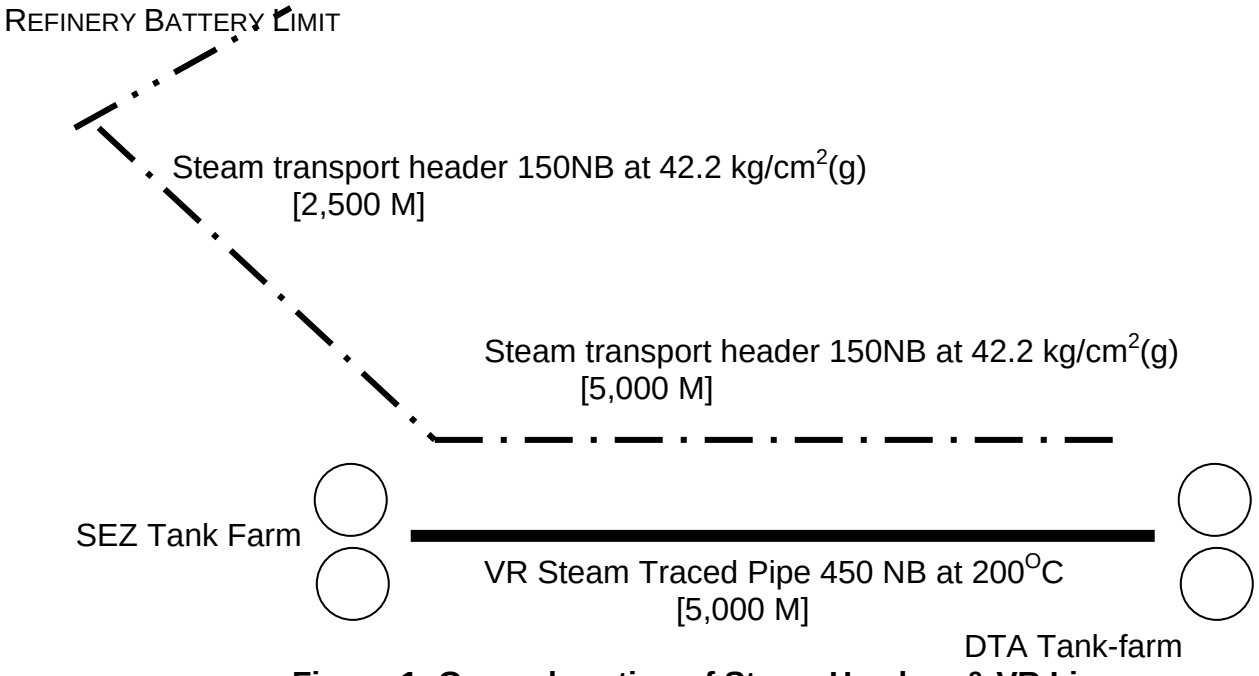


**Figure-1: General routing of Steam Headers & VR Line**

## *2.5 Thermal Bonding Material for Steam Tracers*

For an effort to possibly maintain VR pipe at 200$^{O}$C, thermally bonding material between steam tracer and VR pipe, would be desirable.

## 3.0 Total Operating Cost (TOC) of Steam Tracing System

The Operating cost for Steam Tracing system for a 5,000 M 450NB (18" dia.) at maintain temperature of 200$^{O}$C, considers the costs towards:

a) Steam consumption due to heat transferred to process fluid by thermally bonded Steam tracer; heat loss from the steam tracer to ambient through thermal insulation; steam required for operation of steam trap; and radiation loss from valves and fittings.
b) Steam consumption due to Radiation losses to ambient from Steam & Condensate Manifolds; and steam & condensate connection pipes to respective manifolds.
c) Radiation losses Steam Feeding Header, which runs parallel to VR pipeline, to transport steam supply for the steam tracing system along the 5,000 M run; losses through the steam trap assemblies.
d) Radiation losses from Steam Transport Header to transport Steam from Refinery battery limit to the SEZ tank-farm of 2,500 M length at 42.2 Kg/cm$^2$(g)
e) Steam Leakages from the entire steam supply and steam tracing network.
f) Maintenance Cost
g) Replacement Cost.

The standards and data considered for the above stated components for Operating Costs of the steam tracing system are explained below.

### *3.1 Steam Consumption from Steam Tracer circuits.*

a) Steam consumption from steam tracer forms the major component of the total steam tracing operating energy cost. Steam consumption towards uncontrolled heat to process fluid is the most significant component.
b) This study has considered steam consumption from thermally bonded 15 NB steam tracer at near about 42.2 Kg/cm$^2$(g) at 0.33991 KG-HR-MTR [.09442 G/S-M] from near to similar conditions corresponding to pipe maintain temperature at 137.6 $^{O}$C from 'Thermal Insulation Handbook – by Turner & Malloy'. Research figures from similar study shows steam consumption from thermally bonded steam tracer at 0.34898 KG-HR-MTR [0.234 lb/(hr) (ft)] for a 10-inch PAN line maintenance at 149 $^{O}$C, ref. 'Design Steam Tracing – Carl Bertram, Vikram Desai and Edward I- CHEMICAL ENGINEERING April 03, 1972. Basic heat transfer study shows similar steam consumption from thermally bonded steam tracer.

c) The energy requirement of Thermodynamic steam trap considered under reasonable load is at 0.25 Kg/hour Steam. Under No-load condition, the energy requirement would be 0.75 kg/hour Steam. [Ref. A Spirax-Sarco guide on 'Steam and Steam Trapping']

## *3.2 Steam Consumption from Manifolds and Branch Lines.*

a) Radiation Losses from an insulated: 40 NB Manifold considered is at 0.052 Kg/(hr)(mtr) steam; 15 NB connecting lines at .047 Kg/(hr) (mtr) steam; 15NB Valves at .023 Kg/(hr) (mtr) steam;

## *3.3 Steam Consumption from 5,000 M Steam Feeding Header*

a) Radiation heat loss from an Insulated 150 NB Steam feeding header is considered at 0.106 Kg/(hr)(mtr) steam.
b) Likewise the losses from steam trap assemblies, as explained above are also considered.

## *3.4 Steam Consumption Due to Steam Leakages*

Steam leakages are synonymous with Steam Systems. The industry norm is that one leak would occur from Steam lines at an average of every 30 meters once a year, and the same has been considered. Accordingly, the study considers the following.

a) Steam leak at 14 kg/cm$^2$(g) from a 1.5 mm diameter leak, from available chart, is considered at 14 kg/hr steam per leakage. Considering the project operating pressure at 42.2 kg/cm$^2$(g), the steam loss due to steam leakages would be higher than the estimated quantity for this study.
b) The average time allowed for steam leakage to continue before the steam leak is fixed, is considered as 96 hours (4 days). The actual steam leakage considered could be much higher than the estimated steam leakage considered for this study, as it may take a longer period to detect and rectify for a remotely located line, such as this one.

## *3.5 Maintenance Cost for Steam Tracing System*

Checking of Valves, Steam Traps once in a month, and to attend to repairs would involve:

a) Estimated maintenance time per Steam Circuits is 12 Man-hours per year.
b) Cost per Man-hour considered is Rs.100 per Man-hour. This could vary from organization to organization.

## *3.6 Replacement Cost for Steam Tracing System*

The operating life of Steam tracing system is considered as 10-years, and accordingly an average of 10% per year of installed cost is considered as Replacement cost.

## *3.7 Summary of Operating Cost for Steam Tracing System*

| | | Steam Consumption Kg/hour | Steam Cost Annual Rs. Lacs |
|---|---|---|---|
| a | Steam Tracer circuits | 10,334 | 587 |
| b | Manifolds & Branch Connections | 194 | 11 |
| c | Steam and Condensate Lines | 565 | 32 |
| d | Steam Leaks | 210 | 12 |
| e | Maintenance | | 8 |
| f | Replacement | | 51 |
| | | | |
| | | | |
| | | | |

# 4.0 Energy Consumption Comparison and Cost

## *4.1 Energy Consumption for SECT Electric Heat Tracing*

a) The Energy consumption for SECT Electric Heat Tracing is considered at Annual Mean Average ambient of 25 $^{O}$C, to estimate the annual energy consumption.
b) Design Margin loading has not been considered for estimating the annual energy consumption.
c) The Energy Cost for Electrical Power considered is **Rs..3.0 kWh** [by CONSULTANT]
d) Annual Operating hours is considered at 8000-hours.
e) Accordingly, the Rate of Power consumption for 450NB (18" dia.) Pipe of 5,000 M length at 200OC is calculated to be 469 kWh.
f) Accordingly, the Annual Power Energy cost is calculated to be at Rs.112 Lacs.
g) The installed electric load has been considered with a 25% Design margin, which is very near about the required to be done. Moreover, the SECT Electric Heat Tracing controls the Energy Power input very near to the actual Heat Loss taking place. Thus, the efficiency of an Electric Heat Tracing system is greater than 90%.

## *4.2 Energy Consumption for Steam Tracing System*

a) The Energy consumption for Steam Tracing system is calculated based on the estimated / calculated: i) Heat input into the Fluid by thermally bonded steam tracer; ii) Heat loss from the steam tracers to ambient through thermal insulation; iii) Radiation and Steam leakages from the entire steam system i.e. Steam Transport and feeding Headers, Manifolds, Pipes and Fittings.
b) The Energy Cost for Steam is considered at Rs..0.71 kg steam/hour [by CONSULTANT @ USD15.8 per MT]
c) Steam Tracing is generally not shut off and opened frequently, as starting of the steam supply is an operation in itself. Therefore, efforts in controlling temperature from a steam traced lines can be done only marginally at a very enormous cost.
d) Against the work required steam load of 1087 kg steam / hour, the Steam energy expanded to do the work is 11,303 kg steam/hour, thus the Steam Tracing System efficiency would run below 10%.

## 5.0 Conclusion Summary

Note, this study has been prepared for Technical and Economic consideration in selection of the choice between Steam Tracing system and an Electric Heat Tracing system. Hence, the design and costs figures considered for a Steam Tracing system are on a conservative side.

a) Electric Heat Tracing and in particular the Skin Effect Heating system such as SECT is the proven and established mode of heat tracing High Maintain Temperature ($200^{O}C$), High Viscosity and High Pour Point fluids long distance pipelines, worldwide.

b) The Electric Heat Tracing system will be quicker to install compared to Steam Tracing system.

c) Total Installation Cost of SECT Electric Heat Tracing system will be less than half the cost of a Steam Tracing system.

d) Total Operating Cost of SECT electric heat tracing system will be a fraction of cost a Steam Tracing system.

e) For SECT Electric Heat Tracing System Design & Cost Refer to SECT Technical Design and Budgetary Estimate Report Rev.02 of October 27, 2006

## 6.0 Reference

***1. Total Installed Cost for Steam Tracing System: Annexure-4***

***2. Total Operating Cost for Steam Tracing System: Annexure-5***

***3. Operating Energy & Cost for SECT Electric Heat Tracing system: Annexure-6***

***4. The Energy Requirements of Steam Traps. [Spirax-Sarco Publication]***

***5. Steam Condensed and Watt Heat Loss per Meter of Tracer,Table 36, page 328,'ThermalInsulation Handbook- by Turner & Malloy'***

***6. Designing Steam Tracing, April 3, 1972/ Chemical Engineering – by Carl G. Bertram, Vikram J. Desai & Edward Interess, The Bedger Co.***

***7. Steam Tracing pages 32 to 37, Steam In The Oil & Chemical Industries.***