'ENERGY & ENVIRONMENT CONSERVATION FOR HEAT TRACING SYSTEMS'

Preamble

Replenishment of heat losses through thermally insulated surfaces, used for storing, handling, transferring and usage of heated viscous, high pour point, solidifying, sensitive and condensing fluids, inside Tanks, Vessels, Pipelines and Instruments, where Low temperature precise heat usage is required, is termed as a 'Heat Tracing' subject. This paper encompasses the proven technology advancements over the conventional methods for Heat Tracing Systems, and covers aspects related to: conservation of substantial energy losses taking place due to conventional rule of thumb and/or standard table design approach; poor, un-optimised heat loss design; inadequate maintenance and operation of the system; whether these be by Steam, Electric or hot circulating fluid Heat Tracing System. Energy Conservation, resulting by way of reduction in electricity, oil, gas or any other form of energy deployed, has a direct bearing in reduction of pollutants released to environment, and impacting upon the Global Warming aspect. The energy losses through Heat Tracing Systems go unheeded, for it is a small part of overall plant investment cost; and, furthermore Heat Tracing System is a composite subject involving several engineering discipline groups: Process group, whose needs and criticality for temperature maintenance of fluids, are known best to them; Piping group, who design and estimate the required Piping with thermal insulation for handling, transfer and plants operations, and in case of Heat Tracing System with Steam, they provide for steam distribution, condensate return and waste heat recovery piping; Electrical group, who take upon the overall responsibility, in the event when an Electric Heat Tracing is the preferred choice, they have to depend on requirements from Process and Piping groups; Instrumentation group, who are now increasingly getting involved with Heat Tracing Systems, due to requirements of Monitoring and Control, demanded by advanced plant operation processes; and, now Safety, Environment & Health group are active in modern complexes. In this complexity, the overall requirement of Heat Tracing System, the holistic overview of Energy & Environment conservation is lost in system selection (steam, electric, hot circulating thermal fluids), optimised heat loss and heat replenishment design, efficient operation and maintenance practices of Heat Tracing Systems. This paper highlights the areas and aspects of how over the past 30-years since 1978, the introduction and usage in India of ***Raychem*** conductive polymer heating core electric heat tracers, having inherent built-in Self Limiting and Self Regulating burnout proof properties has had, and continues to have an impact on Energy and Environment conservation, and also improving the plant process efficiency in handling of difficult fluids, and also offering enhanced safety. This paper also highlights the recent advances that have taken place in system Monitoring and Control, Thermal Insulation techniques, and 21st Century technology products in the Heat Tracing System industry.

Choices amongst Modern Heat Tracing System

a) Conductive Polymer heating Self Limiting Self Regulating (SLSR) Electric Tracers: ***Raychem*** Self Regulating Tracers, invented and pioneered by Raychem Corporation, Menlo Park, California, USA (now, Tyco Thermal Controls), who are the leaders with over a Billion feet installed worldwide, have a conductive polymer fibre heating core for higher maintenance temperature (150 deg.C), and stability at high temperature withstand (up to 250 deg.C); and, a solid conductive polymer core tracers for sensitive low maintenance temperature fluids, meeting safety demands of tracer skin surface temperature as low as T6 Rating (85 deg.C) to prevent auto ignition of surrounding explosive gasses. These SLSR electric heat tracers have Positive Temperature Coefficient (PTC) property, thereby adjusting its power output, such that it provides more power when the fluids are at around ambient or below the fluid maintain temperature; and, the power output reduces as it approaches the designed maintenance temperature, and an equilibrium stage of temperature stabilisation is reached where the heat output equalises with the heat loss from the heated surface, without an aid of an external temperature control device. Thus, these SLSR tracers provide heat where and when needed, along the heat traced surface of complicated pipe network with its pipe fittings, and vessels / tanks having varying fluid levels; a kind of control which no advanced technology control system can achieve.

b) Coiled composite metal alloy heating element, having Positive Temperature Coefficient (PTC) property, with temperature maintenance capability up to, 230 deg.C; and, having field cut-to-length features have been developed, and are now beginning to be installed and operated in India, have great potential benefits on Heat Tracing Systems usage in the industries.
c) Skin Effect Current Tracing (SECT), used for heat tracing of Long Transfer lines (several kilometres), has gained prominence in India with selected users now for around a decade, and it has come of age in India by current installation taking place for Cross Country Lines (of over 500 kilometres) carrying waxy crude oil. SECT systems being installed are designed to maintain 190 deg.C temperatures for viscous Residual (VR) fluids.
d) New generation of Steam tracer tubes that are covered with a special high temperature polymer jacket, and tracer tubes that are covered with composite materials that lower thermal conductance to reduce heat output and temperature, provides for predictable heat output along the traced pipe while preventing hot spots and over heating, are now being used for steam tracing. These steam tracers replaces conventional bare metallic tracers that waste energy, and stress pipe works by raising pipe temperatures much higher than desired, are now in operation in India at selected plant installations.

Energy Efficiency & Conservation in Heat Tracing Systems

The choice of selection and usage of Self Limiting and Self Regulating Electric Heat tracers over Steam Tracing practice on count of Energy Conservation are summarised, from various selected studies covering different heat tracing applications in various industries over the past 30-years since 1978 in India. Steam Tracing System Energy Efficiency would run around at 7% to 15%, whilst the Electric Heat Tracing System Energy Efficiency would run at over 90% efficiency. The prime reason for this is that there are Energy losses during steam distribution, energy losses during utilisation of steam tracing and energy losses from steam utilisation, are cumulatively much higher than the required work to be done towards replenishment of heat losses from insulated surface of pipes, vessels and tanks to be heat traced. The Radiation heat losses from insulated Steam supply mains, Steam and Condensate manifold, and steam losses from un-insulated fittings; steam losses due to steam trap operating energy, and steam leaks are cumulatively way above the required work to be done, i.e., replenishment of heat loss from the thermally insulated heat traced pipe. Table-1, summarises the Ratio of Steam to Electric energy consumption rate for the respective Heat Tracing Systems, for various cases; and Table-1A, shows Steam consumption break-up summary.

Table-1: Summary of Energy Consumption Comparison for Steam Tracing and SLSR Electric Heat Tracing Systems

Latent heat of Steam at 3 kg/sq.cm g: 650.6 kcal/kg
1 kcal/hour equals 0.00116 kW
1 kW equals 860 kcal/hour

pour deg.C	maint. deg.C	pipe NB	pipe mtr	pipe NB	pipe mtr	STEAM TRACING kg/hour	STEAM TRACING kcal/hour	SLSR ELECTRIC TRACING kW	SLSR ELECTRIC TRACING kcal/hour	RATIO Steam to Electric
CASE- 1 Power Station (Yard Piping)										
66	85	80	500	80	500	1109	721515	31.2	26832	26.9
CASE- 2 Power Station (Boiler Area Piping)										
66	85	50	900	50	300	1007	655154	38.8	33368	19.6
CASE- 3 Refinery (LSHS Transfer Line)										
66	85	250	1500			2791	1815825	45	38700	46.9
CASE- 4 Refinery (ASPHALT Transfer Line)										
66	120	250	1500			4455	2898423	73	62780	46.2
CASE- 5 Process Industry (Unload & Transfer Yard Pipe)										
66	85	100	50	80	450	294	191276.4	7.85	6751	28.3
CASE- 6 Refinery (OBL Transfer Pipe)										
78	190	600	3000	300	2530	18483	12025040	807	694020	17.3

Table-1A

Steam Tracing System: Steam Consumption Breakup Summary

pour deg.C	maint. deg.C	pipe NB	pipe mtr	pipe NB	pipe mtr	STEAM TRACER NO FLOW kg/hour	STEAM TRACER FLOW kg/hour	STEAM TRAPS kg/hour	STEAM MAINS kg/hour	STEAM LEAKS kg/hour	TOTAL STEAM kg/hour
CASE- 1 Power Station (Yard Piping)											
66	85	80	500	80	500	66	536	125	130	252	1109
CASE- 2 Power Station (Boiler Area Piping)											
66	85	50	900	50	300	53	428	162	162	202	1007
CASE- 3 Refinery (LSHS Transfer Line)											
66	85	250	1500			323	1506	66	645	251.0	2791
CASE- 4 Refinery (ASPHALT Transfer Line)											
66	120	250	1500			645	2409	235	665	501.0	4455
CASE- 5 Process Industry (Unload & Transfer Yard Pipe)											
66	85	100	50	80	450	36	30	21	117	90.0	294
CASE- 6 Refinery (OBL Transfer Pipe)											
78	190	600	3000	300	2530		13011		5471		18482

Power Savings when SLSR Electric Tracing is used in preference to Steam Tracing, with ***Steam Usage from Back Pressure Cycle of Condensing Turbines in Thermal Power Stations.***

It is a common perception that the steam is virtually free when the steam is extracted from a mid-way stage backpressure turbine, of a condensing turbine cycle, for steam tracing and or other utility application usage. In reality, it is not so, as the maximum power is extracted from a condensing turbine.

For a main steam condition at turbine inlet being at 175 kg/cm.sq (g) at 510 deg.C, and when the steam is extracted from a back pressure turbine cycle at 40 kg/cm.sq (g), and pressure reduced to 25 kg/cm.sq (g) for auxiliary usage, then one-ton of Steam would have generated 82.43 kW power.

For a main steam condition at turbine inlet being at 175 kg/cm.sq (g) at 510 deg.C, and when the steam is allowed to complete the cycle through a condensing turbine cycle at 2.5 inch Hg Absolute, then one-ton of Steam would have generated 280.9 kW power. Therefore, it is very important to use steam efficiently for steam from backpressure turbines; and for heating systems where electric systems are more efficient compared to an alternate steam system, then the preferred choice would be for an electric system. Table-2 provides figures of additional power generated when SLSR Electric Heat Tracing is preferred over steam tracing, for examples considered in table-1.

Table-2

Summary of Power Savings when SLSR Electric Tracing is Preferred over Steam tracing, in Thermal Power Plants

Power Extracted from Turbine inlet at 175 kg/sq.cm at 510 deg.C to extraction at 40 kg/sq.cm
1 Ton steam extracts 82.42 kW

Power Extracted from Turbine inlet at 175 kg/sq.cm at 510 deg.C to extraction at 2.5 inch Hg Abs
1 Ton steam extracts 280.9 kW

(A) SAVINGS IN POWER GENERATION WHEN S.L.S.R. ELECTRIC TRACING IS PREFFERED OVER STEAM TRACING IN THERMAL POWER PLANTS.

						POWER REQUIRED SLSR ELECT TRACING	EXTRACTION OF POWER FROM STEAM USED FOR STEAM TRACING		POWER SAVINGS BY SLSR ELECTRIC TRACING (A)	
pour deg.C	maint. deg.C	pipe NB	pipe mtr	pipe NB	pipe mtr	kW	STEAM kg/hour	POWER kW	KW	%
CASE- 1										
Power Station (Yard Piping)										
66	85	80	500	80	500	31.2	1109	220.1	188.9	86%
CASE- 2										
Power Station (Boiler Area Piping)										
66	85	50	900	50	300	38.8	1007	199.9	161.1	81%
CASE- 3										
Refinery (LSHS Transfer Line)										
66	85	250	1500			45	2791	554.0	509.0	92%
CASE- 4										
Refinery (ASPHALT Transfer Line)										
66	120	250	1500			73	4455	884.2	811.2	92%
CASE- 5										
Process Industry (Unload & Transfer Yard Pipe)										
66	85	100	50	80	450	7.85	294	58.4	50.5	87%
CASE- 6										
Refinery (OBL Transfer Pipe)										
78	190	600	3000	300	2530	807	18483	3668.5	2861.5	78%

Carbon Dioxide Emission Comparison that from Steam Tracing System, with that of SLSR Electric Heat Tracing System.

The consumption of fossil fuel energy involves five basic processes: i) energy release via combustion in which chemical energy is converted to thermal energy; ii) conversion of energy to alternate forms (i.e. thermal to mechanical and vice versa; iii) energy distribution to places of use; iv) Energy utilisation for specific purposes; v) energy rejection to environment. This paper considers the carbon dioxide emissions to environment by steam tracing system, and electric tracing systems, for case studies that have been presented in table-1 and table-2. Even though carbon dioxide emission per Terajoule (TJ) of electric energy is 231 tonnes of CO_2, and that for Terajoule (TJ) of oil energy, which is used for steam generation, is 84 tonnes of CO_2, the steam tracing system emits 634% to 1626% more CO_2 compared to SLSR electric tracing system, which is due to higher operating efficiency of electric heat tracing system presented in table-1 and table-2. The Table-3 shows summary of CO_2 emissions from Steam and SLSR Electric tracing system.

Table-3

Summary Comparisons of Carbon Dioxide Emissions Reduction by SLSR Electric Tracing when Prefferred over Steam Heat Tracing System.

Latent heat of Steam	at 3 kg/sq.cm g		650.6	kcal/kg
1 kcal/hour		equals	0.00116	kW
1 kW		equals	860	kcal/hour
1 kg		equals	42000	kJ
1 kg Furnace Oil will generate			15	kg. Steam
1 kg oil releases			3.1428	kg. Carbon Dioxide
1 kJ	Equals		0.0238846	kcal
1 kcal	Equals		4.1868	kJ
1 kWh	Equals		**3600**	**kJ**
1 Terajoule	Equals		**1E+12**	**Joules**
1E+12 TJ Electricity Emits			231	tonnes CO2
1E+12 TJ Oil Emits			84	tonnes CO2

(*B) % **CO2 Emmission Savings by SLSR Electric Tracing when preffered over Steam Tracing**

		STEAM TRACING			**CO2 Emmission**	SLSR ELECTRIC TRACING		**CO2 Emmission**	**CO2 Reduction**
pour deg.C	maint. deg.C	kg/hour	Oil kg/hr	kJ	tonnes/hr	kW	kJ	tonnes/hr	**Electric *(B)**
CASE-1									
Power Station (Yard Piping)									
66	85	1109	73.9	3105200	0.2608	31.2	112320	0.0259	
		ANNUALLY tonnes CO2			***2087***			***208***	**905%**
CASE-2									
Power Station (Boiler Area Piping)									
66	85	1007	67.1	2819600	0.2368	38.8	139680	0.0323	
		ANNUALLY tonnes CO2			***1895***			***258***	**634%**
CASE-3									
Refinery (LSHS Transfer Line)									
66	85	2791	186.1	7814800	0.6564	45	162000	0.0374	
		ANNUALLY tonnes CO2			***5252***			***299***	**1654%**
CASE-4									
Refinery (ASPHALT Transfer Line)									
66	120	4455	297.0	12474000	1.0478	73	262800	0.0607	
		ANNUALLY tonnes CO2			***8383***			***486***	**1626%**
CASE-5									
Process Industry (Unload & Transfer Yard Pipe)									
66	85	294	19.6	823200	0.0691	7.85	28260	0.0065	
		ANNUALLY tonnes CO2			***553***			***52***	**959%**
CASE-6									
Refinery (OBL Transfer Pipe)									
78	190	18483	1232.2	51752400	4.347	807	2905200	0.6711	
		ANNUALLY tonnes CO2			***34778***			***5369***	**548%**

Recent Significant Advances in Heat Tracing Systems

a) For an electric heat-tracing system, Central Control and Monitoring has become increasingly important to industrial heat-tracing installations. The reduction in the number of on-site maintenance personnel coupled with the demand for safe and reliable operation has increased the need for centralised access to critical information about the integrity of heat-tracing systems. For improved production quality and higher yields, an increased number of circuits need to be controlled while temperature bands become narrower. A centralised control and monitoring system offers the benefits of monitoring and changing parameters from a single location while maintaining tighter process temperature controls. The control systems are designed to meet objectives of monitoring Temperatures, Ground-fault currents, Operating currents and other valuable information reflecting the integrity of the heat-tracing circuit that are monitored and communicated to a central location – to the right person at the right time. Status, upset and faults in the heat-tracing system are reported to the user with clear messages and alarms, speeding maintenance and recovery.

b) Thermal Insulation system selection, application and maintenance, ensuring dry insulation, at all times, play a vital role in any heat-tracing system. Eighty five percent (85%) or thereabout, of heat-loss prevention is achieved through Thermal Insulation. For insulation of large sized storage tanks, recent advances offer pre-fabricated insulation panels, having double seam interlocking and sealing arrangement, are now coming of age in the Indian industries. Such advanced system, not only performs the insulation function, but also protects the storage tank surfaces and rooftops from corrosion damages.

Summary Conclusion

This paper has highlighted that Heat Tracing systems play a vital role in plant operations. Beside, highlighting the recent Advances in Heat Tracing systems, the paper has impacted upon: a) Consideration and importance of Efficiency and Energy Conservation in selection of heat tracing system; b) that, the steam from backpressure turbine stage of a condensing turbine cycle, used for auxiliary heating application such as heat tracing, is not free, but is very expansive; c) energy conservation by way of selecting an efficient electric heat tracing system, leads to substantial reduction in Carbon dioxide and other pollutants to the environment. There are several thousands of kilometres of heat-tracing systems in operation in India, and few hundred kilometres are added every year. Therefore, this engineering discipline of heat tracing needs education and co-ordination with all engineering groups, to achieve greater efficiency in thermal energy usage which would result in significant contribution in reduction of global warming rate. Sustained education, surveys, workshops dedicated to heat tracing subject could play a vital role in the objectives set forth in this conference on 'Industrial Heating', 2009, by FICCI.

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Currently, Consultant-Heat Tracing to M/s Raychem RPG Ltd. Graduated in B.Sc. (Physics & Mathematics), University of Poona, 1963. Have Steam Tracing and Electric Heat Tracing systems experience since 1963, and have worked and associated with specialists' organisations in the field of heat-tracing: J. N. Marshall & Co. / Spirax-Sarco Ltd, UK; Raychem Corporation, USA; Tyco Thermal Controls; Thermon and Xicon. In the field of Energy Conservation, have specialised experience in Efficient Use of Steam and Heat Recovery from Condensate & Flash Steam. In the field of Environment have specialised in Bio-medical Infectious & Hazardous Waste Management, Handling and Treatment; and, Oil Spill Response Equipments, having been trained at Elastec-American Marine Inc., USA.

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