Should Sheath Temperature Be Used in Assessing Suitability for Plastic Pipe or Temperature Sensitive Fluid Applications?

introduction

The typical heat tracing design is for a carbon steel pipe without any maximum temperature restriction on the fluid inside the pipe or the pipe itself. However, designs are sometimes needed for non-metallic pipes (plastic pipes), carbon steel pipes with liners, and for carbon steel pipes with temperature sensitive fluids. To determine if the design is acceptable, the heat tracer sheath temperature (highest temperature of the system), is often compared to the non-metallic pipe temperature rating, the liner temperature rating or the maximum allowable fluid temperature. The question arises, "Is this correct and should sheath temperature be used in assessing suitability for these situations?"

For the non-metallic pipe application the answer is yes as only first -cut indicator. If the sheath temperature does not exceed the temperature rating of the pipe material, then proceed with the design. If however, the CompuTrace sheath temperature does exceed the pipe rating, a CFD (Computational Fluid Dynamics) or FEA (Finite Element Analysis) is recommended to predict the actual pipe wall temperature. The results may show that the pipe wall temperature under the heat tracer is acceptable; thus eliminating the need to design with multiple lower wattage heat tracers. This will lead to an optimized and more competitive design.

For tracing carbon steel pipes with internal liners or carbon steel pipes containing temperature sensitive fluids, the tracer sheath temperature should not be used as an indicator of the maximum pipe wall temperature, since carbon steel is a good conductor of heat. Heat from the tracer is conducted circumferentially so that there is no localized "hot spot" in the pipe under the tracer. The Pipe Maintain Temperature from CompuTrace should be used.

The following three examples illustrate how optimization can be achieved when an actual pipe wall temperature generated by a CFD or a FEA analysis is used versus the sheath temperature from CompuTrace.

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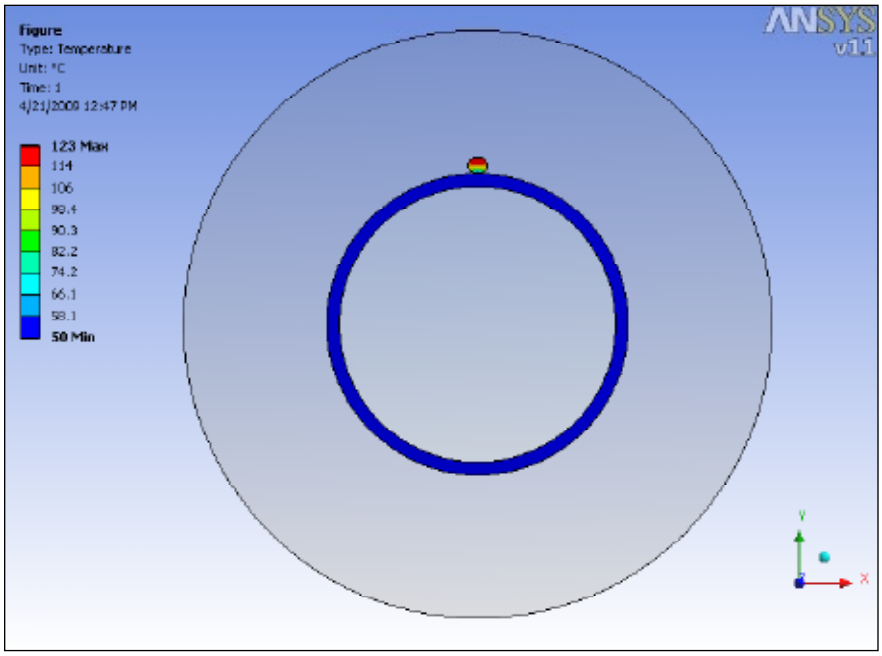
CASE 1: Carbon Steel Pipe with Temperature Sensitive Fluid

An FEA was run for the same conditions as used for CompuTrace. The FEA results also show a heat tracer temperature of 123 ºC. Refer to Figure 1. However, the results also clearly show that circumferential pipe temperatures are quite uniform at or around 50 ºC. There is no localized higher temperature under the heat tracer. Therefore, one pass of the FP 10-2 is an acceptable design.

The CompuTrace results show that the operating cable temperature (heat tracer sheath temperature) is 123 ºC. Refer to Attachment 1. This is well in excess of the 90 ºC maximum allowable fluid temperature. If the heater sheath temperature from CompuTrace were used as an indication of local pipe or fluid temperature, this design with FP 10-2 would be rejected and lower power output option would need to be considered with multiple passes.



Pipe:
150 mm dia

Insulation:
Type: Fiberglass
Thickness: 80 mm

Temperatures:
Min ambient: -20 ºC
Maintain: 50 ºC
Max allowable fluid temp: 90 ºC

Heat tracer:
FP 10-2

CompuTrace® Output: Carbon Steel Pipe with Temperature Sensitive Fluid

Project			Identification			Operating Temperatures		
Job Name			Record	1		Maintenance Temperature	50	°C
Job Facility			Circuit			Pipe Maint Temperature	50	°C
Designer			Line\Pipe			Pipe Maint Temp Hi	n/a	°C
Project Number			Panel\Breaker Number			Operating Cable Temperature	123	°C
Job Number			Isometric Number			Operating Cable Temperature Hi	n/a	°C
						Max Cable Temperature	128	°C
Pipe & Insulation			**Environment**			**Cable**		
Design Heat Loss	24.6	W/m	Min Ambient Temperature	-20	°C	Cable Name	FP 10-2	
Heat Loss w/o SF	20.5	W/m	Startup Amb Temperature	-20	°C	Design Cable Output	30.1	W/m
Pipe Length	35	m	Max Ambient Temperature	40	°C	Cable Output - End of Cable	29.8	W/m
Pipe Size	150	DN	Max Exposure Temperature	n/a	°C	Nominal Operating Power	1081	VA
Pipe Type	Carbon Steel		Max Product Temperature	n/a	°C	Circuit Length	35.5	m
Insulation Thickness	80	mm	Area Classification	Non-hazardous		Total Cable	35.5	m
Insulation Size	169.0	mm	T-Class	n/a		Nominal Operating Current	4.7	A
Insulation Type	Fiberglass		Autoignition Temperature	n/a	°C	Total Maximum Current	4.9	A
Insulation K Value	0.0326	W/m-°C	Temperature Control	Hi Temp Alarm Limit		Voltage	230	Vac
Insul Mean Temp	15	°C	Hi-Limit Set Point	55	°C	Overvoltage	0	%
Jacket Emissivity	0.12		Wind Speed	40	km/h	Trace Ratio	1	
			Safety Factor	20	%	Power Points	1	
No. Valves 0	No. Supports 0		No. Flanges 0	No. Pumps 0		Spiral Pitch	n/a	mm
Valve Allow 2.438 m	Support Allow 0.7 m		Flange Allow 0.17 m	Pump Allow 4.88 m		Circuit Breaker Size	25	
Remarks								

** Current and power values include all passes and power points for each record. Three phase designs display the line amperage for all circuits*

Catalog Number	Description	Quantity	Units	Unit Pricing	Extended Pricing
FP 10-2-OJ	Constant wattage heater cable w/overjacket	35.5	m		
Terminator DP	Non-metallic Power Connection Box	1	each		
(see catalog)	Pipe Sensing Temperature Controller/Control Point	1	each		
(see catalog)	High limit Controller/Control Point	1	each		
PETK-3D	Power and End Termination Kit	1	each		
FT-1H	Fiberglass Cloth Tape	2.38	roll(s)		
CL	Caution Labels	11	each		

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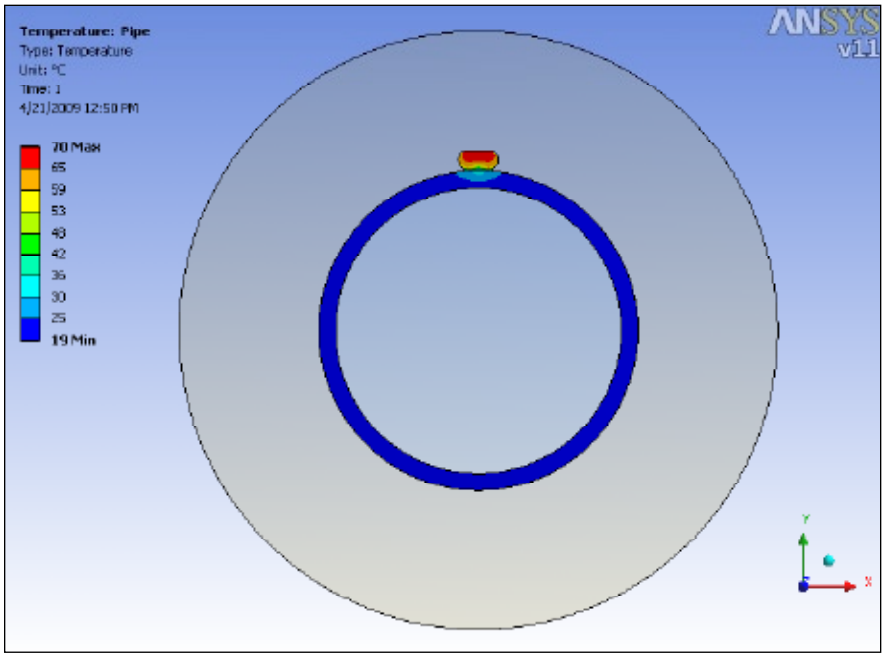
CASE 2: Polyethylene Pipe with Aqueous Solution

An FEA was run for the same conditions as used for CompuTrace. The FEA results also show a heat tracer temperature of 70 ºC. Refer to Figure 2. However, the results show that there is no point on the polyethylene pipe above 60 ºC. As a matter of fact, the highest pipe wall temperature (under the heat tracer) is 30 ºC. This is well below the 60 C max allowable temperature. Therefore, one pass of the BSX 10-2 is an acceptable design.

For this case the CompuTrace results show that the operating cable temperature (heat tracer sheath temperature) is 70 ºC. Refer to Attachment 2. This exceeds the polyethylene pipe maximum pipe service temperature of 60 ºC. If the heater sheath temperature from CompuTrace were used as an indication of the local pipe temperature, this design with BSX 10-2 would be rejected.



Pipe:
100 mm dia

Insulation:
Type: Fiberglass
Thickness: 50 mm

Temperatures:
Min ambient: - 25 ºC
Maintain: 20 ºC
Max pipe service temperature: 60 ºC

Heat tracer:
BSX 10-2 (installed without aluminum tape)

CompuTrace® Output: Polyethylene Pipe with Aqueous Solution

Project			Identification			Operating Temperatures		
Job Name			Record	2		Maintenance Temperature	20	°C
Job Facility			Circuit			Pipe Maint Temperature	20	°C
Designer			Line\Pipe			Pipe Maint Temp Hi	n/a	°C
Project Number			Panel\Breaker Number			Operating Cable Temperature	70	°C
Job Number			Isometric Number			Operating Cable Temperature Hi	n/a	°C
						Max Cable Temperature	74	°C
Pipe & Insulation			**Environment**			**Cable**		
Design Heat Loss	15	W/m	Min Ambient Temperature	-25	°C	Cable Name	BSX 10-2	
Heat Loss w/o SF	13.6	W/m	Startup Amb Temperature	-25	°C	Design Cable Output	15.3	W/m
Pipe Length	35	m	Max Ambient Temperature	40	°C	Cable Output - End of Cable	15.0	W/m
Pipe Size	100	DN	Max Exposure Temperature	n/a	°C	Nominal Operating Power	575	VA
Pipe Type	Polyethylene		Max Product Temperature	n/a	°C	Circuit Length	35.5	m
Insulation Thickness	50	mm	Area Classification	Non-hazardous		Total Cable	35.5	m
Insulation Size	121.0	mm	T-Class	n/a		Nominal Operating Current	2.5	A
Insulation Type	Fiberglass		Autoignition Temperature	n/a	°C	Total Maximum Current	9.0	A
Insulation K Value	0.0310	W/m-°C	Temperature Control	Hi Temp Alarm Limit		Voltage	230	Vac
Insul Mean Temp	-2	°C	Hi-Limit Set Point	30	°C	Overvoltage	0	%
Jacket Emissivity	0.12		Wind Speed	40	km/h	Trace Ratio	1	
			Safety Factor	10	%	Power Points	1	
No. Valves 0	No. Supports 0		No. Flanges 0	No. Pumps 0		Spiral Pitch	n/a	mm
Valve Allow 1.524 m	Support Allow 0.6 m		Flange Allow 0.15 m	Pump Allow 3.05 m		Circuit Breaker Size	15	
Remarks								

** Current and power values include all passes and power points for each record. Three phase designs display the line amperage for all circuits*

Catalog Number	Description	Quantity	Units	Unit Pricing	Extended Pricing
BSX 10-2-OJ	Self-regulating heater cable w/overjacket	35.5	m		
Terminator DP	Non-metallic Power Connection Box	1	each		
(see catalog)	Pipe Sensing Temperature Controller/Control Point	1	each		
(see catalog)	High limit Controller/Control Point	1	each		
PETK-1D	Power and End Termination Kit	1	each		
FT-1L	Polyester Fiber Tape	1.78	roll(s)		
CL	Caution Labels	11	each		

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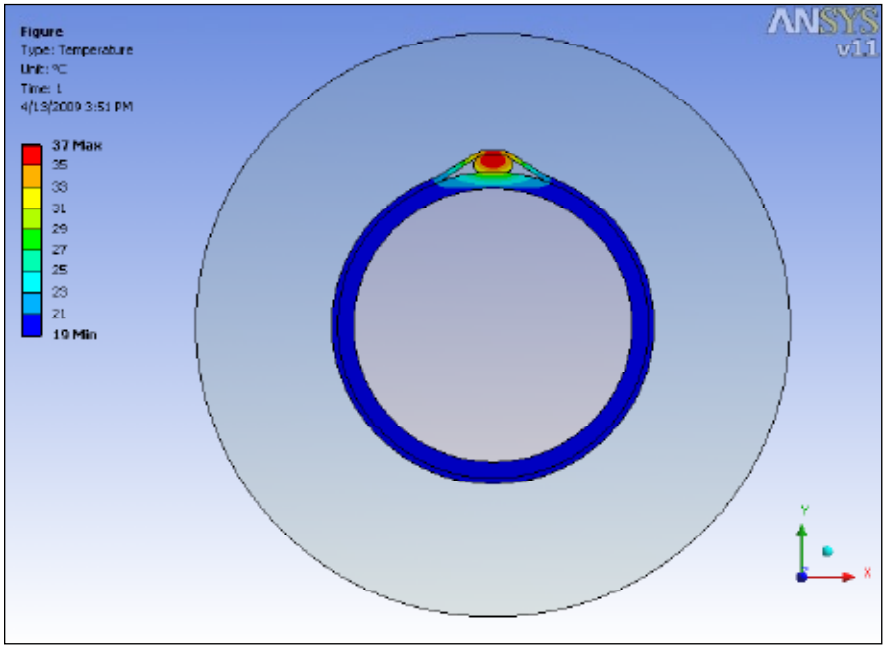
CASE 3: Polyethylene Pipe with Aqueous Solution (AL Tape)

For this case the CompuTrace results show that the operating cable temperature (heat tracer sheath temperature) is 56 ºC. Refer to Attachment 3. This is just below the polyethylene pipe maximum pipe service temperature of 60 ºC, so the design would be allowed. However, an FEA of this design shows that the actual pipe wall temperature under the heat tracer is only 29 ºC, which is well below the maximum pipe service temperature rating. Using aluminum tape on top of the heat tracer provides more efficient heat transfer between the tracer and non-metallic pipe. As a result the BSX tracer operated at a lower temperature and provided more power output. BSX 8-2 could be used instead of BSX 10-2. For non-metallic pipes Thermon recommends installing aluminum tape over the heat tracer. These FEA results show why.



Pipe:
100 mm dia

Insulation:
Type: Fiberglass
Thickness: 50 mm

Temperatures:
Min ambient: - 25 ºC
Maintain: 20 ºC
Max pipe service temperature: 60 ºC

Heat tracer:
BSX 8-2 (installed with aluminum tape)

CompuTrace® Output: Polyethylene Pipe with Aqueous Solution (AL Tape)

Project			Identification			Operating Temperatures		
Job Name			Record	3		Maintenance Temperature	20	°C
Job Facility			Circuit			Pipe Maint Temperature	20	°C
Designer			Line\Pipe			Pipe Maint Temp Hi	n/a	°C
Project Number			Panel\Breaker Number			Operating Cable Temperature	56	°C
Job Number			Isometric Number			Operating Cable Temperature Hi	n/a	°C
						Max Cable Temperature	66	°C
Pipe & Insulation			**Environment**			**Cable**		
Design Heat Loss	15	W/m	Min Ambient Temperature	-25	°C	Cable Name	BSX 8-2	
Heat Loss w/o SF	13.6	W/m	Startup Amb Temperature	-25	°C	Design Cable Output	17.5	W/m
Pipe Length	35	m	Max Ambient Temperature	40	°C	Cable Output - End of Cable	17.2	W/m
Pipe Size	100	DN	Max Exposure Temperature	n/a	°C	Nominal Operating Power	690	VA
Pipe Type	Polyethylene		Max Product Temperature	n/a	°C	Circuit Length	35.5	m
Insulation Thickness	50	mm	Area Classification	Non-hazardous		Total Cable	35.5	m
Insulation Size	121.0	mm	T-Class	n/a		Nominal Operating Current	3.0	A
Insulation Type	Fiberglass		Autoignition Temperature	n/a	°C	Total Maximum Current	7.5	A
Insulation K Value	0.0310	W/m-°C	Temperature Control	Hi Temp Alarm Limit		Voltage	230	Vac
Insul Mean Temp	-2	°C	Hi-Limit Set Point	30	°C	Overvoltage	0	%
Jacket Emissivity	0.12		Wind Speed	40	km/h	Trace Ratio	1	
			Safety Factor	10	%	Power Points	1	
No. Valves 0	No. Supports 0		No. Flanges 0	No. Pumps 0		Spiral Pitch	n/a	mm
Valve Allow 1.524 m	Support Allow 0.6 m		Flange Allow 0.15 m	Pump Allow 3.05 m		Circuit Breaker Size	15	
Remarks								

** Current and power values include all passes and power points for each record. Three phase designs display the line amperage for all circuits*

Catalog Number	Description	Quantity	Units	Unit Pricing	Extended Pricing
BSX 8-2-OJ	Self-regulating heater cable w/overjacket	35.5	m		
Terminator DP	Non-metallic Power Connection Box	1	each		
(see catalog)	Pipe Sensing Temperature Controller/Control Point	1	each		
(see catalog)	High limit Controller/Control Point	1	each		
PETK-1D	Power and End Termination Kit	1	each		
AL-20L	Aluminum Tape	1	roll(s)		
FT-1L	Polyester Fiber Tape	1.78	roll(s)		
CL	Caution Labels	11	each		

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Summary

For non-metallic pipes use the CompuTrace "Operating Cable Temperature" as a first cut. If it is below the maximum service temperature rating for the pipe material, proceed with the design. If not, to optimize the design, a CFD or FEA analysis is recommended to determine the actual pipe wall temperature.

For carbon steel pipe with internal liners or carbon steel pipes with temperature sensitive fluids, do not use the CompuTrace tracer sheath temperature to compare to the liner or fluid temperature limit. Use the "Pipe Maint Temperature".

"Maximum Cable Temperature" as shown in the CompuTrace output is not relevant because for the cases considered the system has a pipe high temperature alarm or a high temperature limiter on the pipe.