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# Initial temperature for flare design

**Evgeny Ivlev**
**Senior process engineer at Sakhalin Energy**

The question is primarily addressed to ones who dealt with plants in sub-arctic climate.

When you depressurize the plant which initial T you take for relief - process T or ambient (which can be as low as -30 C).
Do you assume that plant can stay pressurized, no heat-tracing, at ambient temperature before you blow down? How conservative are you in design?

I could not find answer in API 521, nor in Shell DEP

The point is: lower initial T, lower blow-down T, stronger material (stainless)

Thanks
Evgeny

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**Steven Murphy**
**Independent Oil & Energy Professional**

Steven

Your vessel temperature during blowdown has to stand up to all realistic cases.The most obvious case is that the vessel and its contents will drop in temperature to the minimum ambient temperature. That should be your starting point. Remember, even though the vessels contents becoming extremely cold, this doesn't necessarily mean that bulk metal temperature reach that same cold temperature - thermal inserts can be used in blowdown nozzles etc....

Other approaches are fraught with problems;-

- If you dont use the minimum ambient temperature for design then maybe it can be blowndown before reaching that, but how can you ensure that the vessel will be blowndown and not cool further. In addition, will automatic blowdown on shutdown cause other problems.
- How can the reliability of heat tracing be maintained. I would be amazed if the electrical tracing would pass any SIL type of criteria.

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**Sudeep Roy**
**Head of Production at Addax Petroleum Limited**

Sudeep

Evgeny,

ASME B31.3 is used for designing process piping and not API codes or RPs. That may be the reason why you don't find any mention of this in API Std. 521.

As per ASME B31.3, 'the design temperature of each component in a piping system is the temperature at which, under the coincident pressure, the greatest thickness or highest component rating is required ….' .

Based on this, you may indeed have to design your flare system with an lowest ambient temperatures mentioned in the BOD. But then again, that's not exactly how things are done in the real world. Designs are engineered and analysed based on practical scenario, risks involved, probability/likelihood, cost, and other factors. Good engineering is all about analysing risks and then, design controls and mitigations to ensure that the residual risk is ALARP. Otherwise, you may end up the whole upstream plant for the well shut-in pressure.

For one of the platforms for Sakhalin-2, I do recall some of the requirements to mitigate this scenario. I am sure that it may be similar for the other platforms, OPF and LNG plant as well, though the design temperature may be different for LNG.
1. The scenario has not been overlooked and mentions the likelihood as 'very small but not impossible'.
2. Minimum cooldown temperature has been defined for the whole blowdown section. This is the temperature to which each section can be allowed to cool down by ambient conditions before it is required to be de-pressurised to avoid the fluid temperature exceeding the system minimum design temperature.
3. It allows the operator to make a decision – whether to blowdown the facility immediately because of an anticipated prolonged shutdown or monitor the temperature to ensure the minimum cooldown temperature is not exceeded before the process is restarted.
4. All the critical pipings and components have independent and redundant heat tracing.

Not sure if this answers your query.

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Steven

**Steven Murphy**

**Independent Oil & Energy Professional**

Is this a new facility or are you having to look at an existing facility? If new, then I would still advise using minimum ambient. Your design should still try and keep the cold blowdown gases away from the bulk vessel metal. I feel that any other approach would be problematic in having to justify to all concerned (safety authorities, other members of the client organisation etc etc.) and your schedule would be well and truly blown(down). Your blowdown modelling needs to be as realistic as possible. I know that Saied Rahimi has some decent information on his website.

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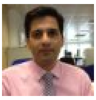

**Saeid Rahimi Mofrad**

**Senior Specialty Process Engineer at Fluor**

Since morning, I was trying to make some free time to join the discussion:

1. The plant can stay in pressurized for quite long time.
2. Not all of equipment are heat traced. Even if it is, there is no guarantee that they will remain functional during this condition.

Therefore, using the minimum ambient temperature as starting point of depressuring is the correct approach.

Nevertheless, the definition of minimum ambient temperature is the least ambient temperature during the coldest period of the year THAT sustains for minimum 24 hours -not the extreme minimum ambient temperature. You need to review site meteorological data to specify this temperature.

It should be noted that this time can be more or less than 24 hours depending on the project/Client criteria on the duration that the system can be maintained in pressurized conditions before being depressurized. The duration that system can be safely kept under pressure is sometime function of service. For example, for compressor vendor input should be obtained.

Most probably un-insulated small vessels will attain the minimum ambient temperature during shut-in duration. However, the large inventory vessels will need more time to reach the minimum ambient temperature and most probably in reality the vessel content temperature will follow the ambient temperature with some margin and time lag depending on the system heat content and the total heat transfer rate.

Any way, a detail heat transfer calculation is required to specify the minimum system temperature in shut-in condition.

I remember a huge multiphase vessel where detailed heat calculation revealed that the vessel fluid temperature flocculated 5 degree above and below the average day and night ambient temperature after being isolated for a long time.
For example, based on site data:
• minimum ambient temp during the day: 0°C
• minimum ambient temp during the night: -20°C

Based on the heat transfer calculations:
• minimum vessel temperature during the day: -5°C
• minimum vessel temperature during the night: -15°C

Taking credit of such calculations needs Client’s approval.

To prevent very low temperatures in such conditions and the respective problems (exotic material, ice and hydrate formation, etc) in process and flare sides, temperature monitoring and automatic depressuring can be employed subject to the approval of the Principal.

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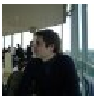

Evgeny

**Evgeny Ivlev**

**Senior process engineer at Sakhalin Energy**

Thanks everyone for very valuable input.

I raised the discussion as I modelled blowdown into new flare and indeed the material selection is just on the border between LTCS and stainess. In fact it is pretty much affected by initial temperature prior to blowdown.

So I was thinking how to overcome this problem

- Rewrite the shut-down procedure-monitoring the temperature during shut-down and blowdown if drops low
- Put SIL3 temperature control for automatic blow down at low T
-Reduce blowdown volume by Increasing sectionalisation of the plant for example
-limit depressurisation rate (by orifice plate for example)
or something else

Nether Heat tracing nor insulation are now adding a credit. this is for sure.

I will keep on studying this and will revert later to the issue

thanks again

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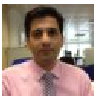

**Saeid Rahimi Mofrad**

**Senior Specialty Process Engineer at Fluor**

Dear Evgeny,

It seems you are on the right track. Only one point about the following solution you have proposed:

'-limit depressurisation rate (by orifice plate for example)

I understand the effect of slow depressuring on the system minimum temperature but as long as the fire case is applicable to the system, the orifice size will be specified by fire criteria (reaching a safe pressure within 15 minutes typically). Adiabatic calculations will be done based on the fixed orifice size; therefore you are not allowed to reduce the size of orifice to get the desired temperature.

Hence, I don’t think this is viable solution for automatic depressuring system.

However, if the system is equipped with the manual depressuring, operator will have the option to throttle the globe valve in order to lengthen the depressuring time (which is hard to rely on, I guess).

Regards,
Saeid

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Evgeny Ivlev likes this

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Sudeep

**Sudeep Roy**

**Head of Production at Addax Petroleum Limited**

Evgeny,

I will like to add some more information and clarification on what I have mentioned earlier, based on the existing philosphies for offshore facilities. I'm sure that the existing philosphies will be extended to the new project as well, if it is for a new facility.

If you allow the process temperature to drop to ambient conditions, there are other issues to deal with as well - water in the separators, produced water system, water injection system, CRI and water injection wells, air gap, etc. Ice formation in any of these systems is most likely to cause delay in the start-up, if not a major damage to plant and equipment. That's one of the reasons why it was not recommended to keep the plant pressurised on prolonged shutdown in winter conditions and numerous interventions are carried out in such a condition including injecting base oil in WI and CRI wells. You can refer to the 'Intervention Requirements for Winter Shutdown' and the 'Winterisation Philosophy' for other assumptions and reasons for doing the same.

The Shell DEP on Design of Pressure Relief, Flare and Vent Systems does state that 'If the temperature is just below a point at which a more expensive (higher alloy) material would be required, more detailed calculations can be performed taking into account the heat transfer from the flare header wall and taking into account the fact that the flare gas velocity will not remain at sonic velocities. The use of carbon steel may be possible where piping stresses are limited by design'. I am sure that you have already done this.

Regards.

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S M

**S M Kumar**

**Process Design Consultant**

Interesting question Evgeny. I agree with Steven and Saeid, inital T should be minimum ambient temperature; inital pressure can be scaled down by Pintial = Pshut-in or PAHH*Tmin/Tnormal.

You are better off here. Few years back clients used to ask for repressurization after a blowdown and then another blowdown - to account for a failed restart. That means the source vessel will have reached its min blow"n"down temperature and that becomes the starting T.

If you consider heat transfer from metal to metal; ambient warmth to into header, you make you get out of SS to LTCS. But once ice forms on the external pipe, it acts as an insulator and prevents warm-up. Simulation programs predict a low value than real. The metal mass in a flare system is huge and the gas back fills and transfers heat or cold to all the pipes that are not in the flow path too. Like dropping a cube of ice in a bucket of water and expecting the bucket of water to freeze. Better analysis is the key. In the past in a couple of cases I used detailed analysis provided by Imperial College, UK services with their Blowdown model to avoid material changes.

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Mojtaba Habibi likes this

Steven

**Steven Murphy**

**Independent Oil & Energy Professional**

Other elements that come into play with your material selection issue. You will probably find that there is very little cost difference between the installed cost of a 316L stainless system and a low temperature CS system. Other favourable factors with the stainless system are that possible future blowdown systems - new compression systems that you may add in the future - won't cause a problem if you have already used a lower spec material and stress designed the pipework to cope with the lower temperature. The carbon steel roughness factor when used in the design will usually mean that you need larger pipe sizes. There are also the future inspection issues/maintenance issues that you would have to put up with for a CS system. Putting it simply - if I had the choice of material to be used for a new flare system, then I would almost certainly go for 316L.

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Mojtaba Habibi likes this

S M

**S M Kumar**

**Process Design Consultant**

Excellent comment Steven. Very valid and very true. I wish I had added that to my comment.

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