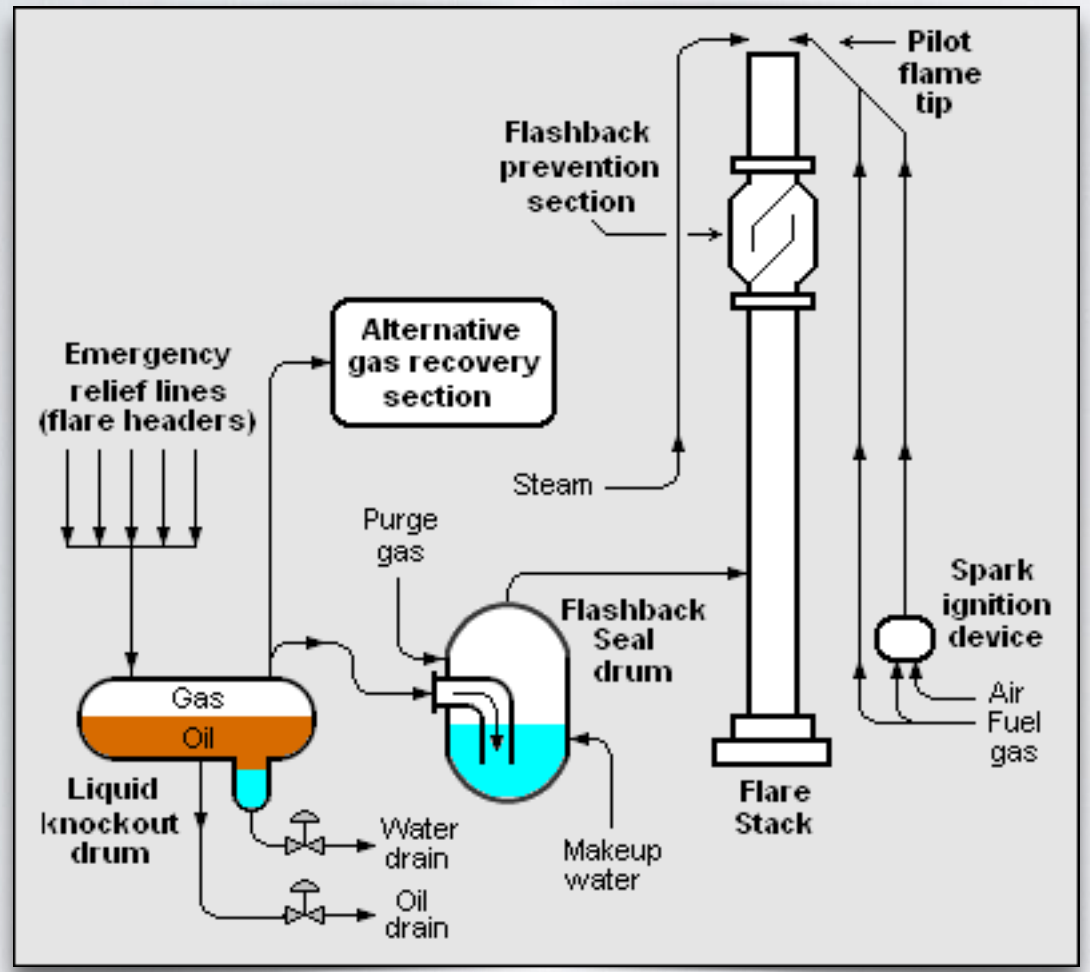
Technical Bulletin

Fire-Protection Insulation Systems per API 521

- The American Petroleum Institute (API) is an industry association of over 600 member companies. The organization's website www.api.org states, "API represents all segments of America's oil and natural gas industry." and "API's mission is to promote safety across the industry globally and to influence support of a strong, viable U.S. oil and gas industry."
- API publishes numerous consensus standards documents to assist engineers and plant operators to increase safety and promote best practices to decrease risk. One such document is titled "*API Standard 521 Pressure-relieving and Depressuring Systems.*" This copyrighted document must be purchased directly from API or one of its authorized distributors.
- "This standard is applicable to pressure-relieving and vapor depressing systems. Although intended primarily for oil refineries, it is also applicable to petrochemical facilities, gas plants, liquified natural gas (LNG) facilities, and oil and gas production facilities."
- API 521 "specifies requirements and gives guidelines to the following:"
    - "Examining the principal causes of overpressure, determining individual relieving rates; and selecting and designing disposal systems, including such component parts as piping, vessels, flares, and vent stacks."



https://en.wikipedia.org/wiki/Gas_flare

- Traditional methodology assumes during a fire outbreak that an emergency pressure relieving event is inevitable due to the rapid heating and vaporization of stored volatile fluids and gases.
- This time-tested system ensures the rapidly heated stored fluids and gases are quickly released by pressure relieving valves (PRV), into liquid knockout drums and flashback seal drums with the excess gases being quickly burned off by a flare stack.

Specifying Fire-Protection Insulation Systems

- One of the lesser known or understood sections of the API 521 Standard is section **4.4.13.2.7 External Insulation.**
- It states (emphasis added), "Credit for thermal insulation **is typically not taken because it usually does not meet the fire-protection insulation requirements** given in 4.4.13.2.7.2 through 4.4.13.2.7.4. **If these requirements are met, a reduction in fire input can be obtained by using the environment factor.**" While it is true that most industrial insulation systems do NOT meet the requirements, it is also clear that systems CAN be designed with the correct components to withstand the extreme fire protection conditions listed in the report.
- Section 4.4.13.2.7.2 clearly outlines the requirements of the insulation SYSTEM for it to qualify as "fire-protection" for the purposes of reducing the potential of a rapid expansion of stored fluids or gases during a fire outbreak. The system includes the insulation, attachment method, cladding and any accessories to help the system to remain attached and intact to protect the vessel from rapid heat gain during a fire. This method may allow for a reduction in the cost and footprint of the pressure relieving system.

Technical Bulletin

Physical Property Requirements of Insulation System

- The system must be able to function effectively at temperatures up to 1660°F (904°C) for up to two hours.
- Corrosion Under Insulation (CUI) must be considered when installing any insulation.
- The system must remain intact and not be dislodged by high pressure water streams during firefighting operations.
- The insulation system must be able to withstand direct flame impingement.
- The insulation must be attached with stainless steel bands and then clad with stainless steel jacketing.
  - Aluminum banding and/or jacketing is NOT acceptable because it will melt at 1,220°F (660°C)
- Table 6 provides a list of typical thermal insulations with thermal conductivity values and maximum continuous usage temperatures.

Insulation Type	ASTM Standard	Max Continuous Operating Temp
Calcium Silicate	ASTM C533 Type I	1200°F (650°C)
Calcium Silicate	ASTM C533 Type II	1700°F (926°C)
Mineral Fiber w/ SS Metal Mesh	ASTM C592 Type II or III	1200°F (650°C)
Cellular Glass	ASTM C552 Type I	900°F (482°C)
Expanded Perlite	ASTM C610	1200°F (650°C)

- All of the listed insulation materials will meet the fire-protection criteria when attached and clad with stainless steel bands and jacketing.
- TPSX-12® type I calcium silicate is the lowest cost insulation option with the most optimized set of physical properties for this application including:
- Best thermal protection >600°F, inherently non-combustible, highest mechanical strength and integral corrosion inhibiting chemistry to limit CUI.

Maximum Continuous Operation vs. Fire Event

- The maximum CONTINUOUS operating temperature limits of type I calsil, expanded perlite and mineral wool metal mesh blanket are 1200°F and cellular glass is only rated up to 900°F continuous. However, properly designed system assemblies can survive a two-hour excursion of 1660°F during a fire when attached and clad with stainless steel bands, springs and jacketing.
- Type I calcium silicate is formed with a Tobermorite crystal structure that gives it excellent heat resistance, high compressive and flexural strength, opacifiers to block radiant heat and an inherently non-combustible nature.
- At extremely high temperatures during a petroleum fire, the outer layer of type I calsil will simply shrink in an endothermic reaction by releasing some of its stored water. This creates a slight cooling effect in accordance with the thermal gradient created by the installed thickness of the insulation system. Calsil will not melt, generates no smoke and will not spread flame per ASTM E84.
- Therefore, the contractor should always install the calsil in two layers so if the outer layer shrinks during a fire, the inner layer joint will be offset and not have a direct path to bare metal. Stainless steel springs installed on each band ensure the system remains tight to the vessel as the outer layer of calsil shrinks. This allows fire fighters more time to extinguish the fire.

Technical Bulletin

TPS Material Offerings

- TPS currently offers several distinct types of high quality industrial insulations to the market including:
  - TPSX-12® Calcium Silicate per ASTM C533 type I
  - TPS EP-12™ Expanded Perlite per ASTM C610
  - TPS Phenolic Foam per ASTM C1126 type III
- TPS agrees with section 4.4.13.2.7.1 "Credit for thermal insulation is typically not taken because it usually does not meet the fire-protection insulation requirements…" However, there are certain insulation material assemblies that will survive a fire event.
- Phenolic foam would NOT meet the fire-protection insulation requirements of API 521 because it is a foam plastic.
- Expanded perlite per ASTM C610 is listed in Table 6 and would meet the requirements if installed as a component of a system.
  - Caution: due to the natural composition of perlite ore as a volcanic glass, prolonged exposure to extremely high temperatures could result in the expanded perlite insulation softening or melting through vitrification.
- Calcium silicate (calsil) per ASTM C533 type I would provide the most optimized set of physical properties combined with the lowest installed cost compared to the other insulation types listed in Table 6 of the API 521 Standard Document.

Design Methodology

- The goal is to "buy time" to allow fire fighters to extinguish the blaze before the stored fluids are raised from the operating temperature to the point where the fluids will vaporize and initiate an emergency pressure relieving and flaring event.
- The actual total insulation thickness shall be determined by the Engineer of Record by using the section **4.4.13.2.7.4 Environmental Factor for External Insulation** calculation based on the thickness and thermal conductivity of the specified insulation along with the temperature of the vessel contents at relieving condition.
- Section **4.4.13.2.4.2 Heat Absorption Equations for Vessels Containing Liquids** shall be calculated utilizing the derived Environment Factor (F). If the resulting heat absorption (Q) to the wetted surface area of the vessel exceeds the amount of heat needed to raise the volume of the stored fluid from the operating temperature up to the relieving temperature, then add more insulation thickness until a reasonable factor of safety is achieved.

Assembly Recommendation

- Metal component asset (i.e. pressure vessel, tower, storage tanks or bullets)
  - Coating system if required shall be specified separately by others
- Install a minimum of two layers of 2" (50mm) thick (4" total thickness) calcium silicate per ASTM C533 type I OR expanded perlite per ASTM C610 rigid thermal insulation with joints offset from previous layer.
  - All joints between insulation sections shall be tightly fitted to minimize gaps
    - Small gaps or voids <1/2" shall be filled with high temperature insulating cement
    - Large gaps or voids >1/2" shall be filled with loose fill ceramic fiber
- Each layer of insulation shall be secured individually to the metal asset with 3/4" wide T304 stainless steel bands and wing seals.
  - Each band shall be fastened through T304 stainless steel springs such as:
    - Insul-Mate™ CS-6 Compression Springs or Insul-Mate™ ES-7 Expansion Springs by RPR Metals
- Insulation shall be covered with T304 stainless steel jacketing per ASTM C1767 type I, grade 1, class A.
- Stainless steel jacketing thickness shall be in accordance with Table 2 of ASTM C1767 and based on the outer insulation diameter.
  - Example: Insulation OD over 36" shall be installed with 0.020" nominal thickness of stainless steel jacketing.
- Jacketing shall be installed and banded over the insulation using the same 3/4" wide T304 bands, wing seals and springs.
  - Jacketing shall be overlapped both circumferentially and longitudinally with a minimum of 3" overlap.
  - T304 stainless steel screws or rivets shall be installed on the horizontal jacketing seams between the bands.