A First Step Towards Ensuring Mechanical Integrity - Pipe Classifications Using API 570

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In the current, resource limited economic environment, operators face significant challenges when assigning inspection resources that ensure the mechanical integrity of process piping and equipment. The frequency and extent of inspections conducted on process piping circuits depends upon the damage mechanisms active within the circuit and the consequences of a piping failure. A Risk Based Inspection (RBI) assessment strategy that evaluates the probability of failure and the potential explosion, fire, toxicity, and environmental consequences of a loss of containment can be used to set inspection intervals.\footnote{1} American Petroleum Institute (API) 570, Piping Inspection Code also outlines a simplified classification system and corresponding maximum inspection intervals based on the consequence of failure.\footnote{2} According to this scheme, process piping is divided into four general classes with a separate category for injection locations. Inspection frequencies should not exceed one-half the remaining life and, at a maximum, can range from a minimum of five years for Class 1 piping (for thickness measurements and external visual inspections) up to a no-required-minimum inspection interval for Class 4 piping. Accurate classification of process piping directly impacts the frequency and intensity of inspections and should be consistent with the risk management program of the facility and good engineering judgment of personnel who set the pipe classifications. As an aid, API provides a limited list of examples within each pipe class to assist personnel performing the classification.

Owners and operators of process piping systems are permitted to use the simplified classification scheme in conjunction with measured corrosion rate and remaining life calculations if they have not developed an RBI program. The intent is to focus extra inspection efforts on process piping that has the highest potential consequence(s) in the event of a loss of containment. According to API, services with the highest potential for immediate emergency if a leak occurs should be designated Class 1. The phrase \textit{“highest potential for immediate emergency”} is deliberately ambiguous so that each facility can independently determine which piping falls under this criterion. Class 2 should include the majority of the process piping within a typical petrochemical unit and should be assigned for piping not included in other classes. Class 3 includes services that are flammable but do not significantly vaporize when they leak or the piping is installed in a sufficiently remote location such that loss of containment has relatively little consequence. Process piping containing nonflammable and nontoxic streams is assigned Class 4.

API 570 provides examples of certain physical properties, including the boiling point and vapor pressure, as criteria for certain services included within each pipe class. With greater understanding of process hazards, risk management, and asset integrity, the examples provided for each pipe class have evolved over successive editions of the code. For example, in the first edition (1993), examples of Class 1 piping included fluid in pressurized service that create vapors that collect and form explosive mixtures including C2, C3, and C4 streams. In the 2003 addendum for the 2nd edition, these examples were further expanded to include fluids with boiling points below 50°F. In the third and fourth editions (2009, 2016), examples included streams whose operating temperature was greater than their atmospheric boiling point.

API 570 also suggests flash point and autoignition temperature criteria for examples of certain pipe classifications. Examples of Class 1 piping in the 3rd edition included fluids that operate above their atmospheric boiling point or their auto-ignition temperature. Examples of Class 2 piping included fluids operating below their flash point. API clearly states that their examples are not all-inclusive and owner/operators are expected to develop their own classifications schemes based on the information...
provided in API 570. Nonetheless, based on these examples alone, API created an area of ambiguity regarding how to classify process piping in which the operating temperature is above the flash point and below the boiling point or auto-ignition temperature.

The recently released fourth edition of API 570 (2016) has resolved this ambiguity by retaining the examples of hydrocarbon services operating above their boiling point and/or their autoignition temperature as Class 1 piping and clarifying that services operating below the boiling point but above the flash point should be designated as Class 2. Additional clarification within this temperature regime is included via the explicit example of gasoline. Process piping containing gasoline at ambient temperature is considered Class 2, since it is above its flash point but below its autoignition temperature. However, gasoline services at high processing temperatures (e.g. 550 °F) should be included within Class 1.

If an RBI piping inspection plan has not been established by an owner/operator, existing pipe classifications should be reviewed to ensure that they are compliant with the guidance in the most recent version of API 570. It is possible that certain refineries may have identified process piping as Class 2, when Class 1 may be more appropriate (and vice versa). Reviewing and updating pipe classifications to be consistent with the current version of API 570 provides owners and operators the opportunity to revisit their inspection strategy and update the frequency and extent of inspection for a given piping system as necessary.

The updated classification scheme requires owners and operators to better understand the properties (e.g., autoignition temperature, boiling point, flash point) of their process streams so that they can appropriately classify process piping. The figure below demonstrates some of the nuances in correctly identifying the appropriate class of process piping. The autoignition temperature, boiling point, and flash point of n-alkanes is plotted as a function of molecular weight. It is clear that for certain heavier hydrocarbons, the autoignition temperature can fall below the boiling point. In these cases, the owner operator should recognize that proper classification will depend on whether the service operates above the autoignition temperature (Class 1) or below the autoignition temperature (Class 2). Refinery process streams are typically complex mixtures of hydrocarbon species; therefore, the explicit determination of autoignition temperature, boiling point, and flash point might be necessary.

![Figure 1. Autoignition Temperature, Boiling Point, and Flash Point of n-Alkanes](image-url)