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PLANT PIPING SYSTEMS DESIGN CRITERIA within the steam generation unit and power station plant designed in accordance with ANSI B (PROJECT STANDARDS AND.

X20 was introduced in the s in Germany and used in steam lines operating at temperatures of degrees C and higher for fossil fuel-fired power generating sets of megawatts and more. However, two factors limited its use: P91, introduced in the s in the U. These features have made P91 the material of choice for high-temperature steam and other, similar noncorrosive services. X20 Material X20 material was first used in India for high-temperature steam piping around The next application in India took place nearly two decades later, when the Tata Electric Co. These reductions resulted in easier handling; less energy needed for preheating, welding, and postweld heat treatment; and faster start-up, load changes, and shutdown of the unit. Overall savings in the cost of the piping supplies and their fabrication, including welding, was claimed to be about 40 percent. Since then X20 has been used in India for main steam piping in six other power stations. By the time P91 was included in the ASTM specification A in , more than , metric tons of X20 tube and pipe had been used in power stations worldwide. The cumulative operating time with the material steel had been more than 4 million hours. This is likely one of the main reasons that the U. P91 Material When properly heat-treated, P22, X20, and P91 achieve these tensile properties at room temperature. Development of any new material, especially for high-temperature service, requires many years, because creep rupture strengths are established based on longtime exposure to a range of intended service temperatures. As a result of these developmental efforts, a new material, designated P91, was introduced in the U. This material has proven to have such good strength and fabrication properties that the use of X20 has practically been discontinued in Europe. In fact, even renovations of old power plants are being made with P91 material for steam circuits operating in the creep range. P91 is a modified form of P9 9 percent chromium, 1 percent molybdenum steel. The steel can have low impurity limits, thanks to the development of processes such as argon-oxygen decarburization AOD and electroslag remelting ESR , which make the steel behave consistently during fabrication and resist the effects of aging. When properly heat-treated as specified in ASTM specification A, the steel acquires room temperature properties as shown in Figure 1. The steel has high creep rupture strength because of the precipitation of submicroscopic vanadium and niobium carbonitrides. Low carbon content aids its fabrication characteristics. The material responds well to hot and cold bending, as well as to welding. Comparison of X20 and P91 Figure 2 P91 top and X20 bottom both are martensitic steels with similar transformation behavior. P91 and X20 both are martensitic steels with similar transformation behavior see Figure 2. Martensite formation temperature for P91 is about degrees C. Welding of P91 steel is, therefore, carried out below this temperature using preheat and interpass temperatures in the range of to degrees C. The maximum hardness in the weld metal and heat-affected zone in as-welded condition is about HV10, which is lower than that of X20 greater than HV Heavier-wall P91 components may be cooled to room temperature after welding. The joint should, however, be kept dry after welding until postweld heat treatment is complete to avoid stress-corrosion cracking caused by the presence of humidity. The higher temperature helps prevent high hardness values and the attendant risk of cracking during welding. In any case, except for very thin-wall components, X weld deposit must be cooled down to about degrees C and held there for at least one hour for the transformation of austenite into martensite to be complete. The component then is subjected to a tempering treatment at between and degrees C for at least two hours. Figure 3 Several brands of welding consumables can be used with P22 and P91, while only one brand is recommended for use with X Following are some considerations that influence a choice between P91 and X The allowable stress is increasingly higher for P91 at higher temperatures. Therefore, any advantages of X20 based on its lower thickness requirement can be obtained by using P91 at degrees C and higher. Use of X20 demands extreme care in fabrication and welding of the piping components. Important parameters include induction heating of thicker weld joints; special cooling and storage of bends before heat treatment; low-speed grinding performed intermittently to prevent overheating and cracking; completion of welding and heat treating in one cycle; and extensive NDT for weld joints. The thermal expansion coefficient of P91 is comparable to that of X The thermal conductivity of P91 is higher than that of X P91 can be readily machined with cutting tools similar to those used for X P91 has a lower chromium content, which helps to conserve material. Figure 4 Several types of nondestructive testing typically are recommended for P Confidence in the use of P91 steel has grown substantially since its first use. T91 in and A Gr. Inclusion of P91 plates, forgings, flanges, and fittings in ASTM standards, and commercial manufacture of such components to these standards, continues to evolve. It now is possible for fossil fuel-fired power stations to achieve higher pressure and temperature parameters on main steam piping, and thereby realize higher thermal efficiency, using this material. This saves recurring fuel costs and also reduces pollutants, because less fuel is burned. T91 also is being applied in superheater and reheater circuits, which used to require austenitic steel because of the design temperatures. P91 also has been used recently in petrochemical plants for cracking and hydrotreating furnaces that employ higher operating temperatures to increase the yield of unleaded, high-octane fuels. P91 has a promising future, and its applications are sure to increase until another new material is in a position to challenge it. BHEL is an engineering and manufacturing organization engaged primarily in design, manufacture, supply, installation, and servicing of power plant and industrial equipment. You May Also Like.

Chapter 2 : The Evolution of Steam Attemperation

geothermal power plant can be divided in piping inside the power plant and the piping in the steam field. Piping in the steam field consists of pipelines connecting the production wells to the separation station.

There are several factors that impact the reliability, performance, longevity, and maintenance requirements for the condensate piping system. Some of these factors are listed below: Condensate line sizing that factors condensate liquid, and flash steam quantities. Location of the condensate line with respect to the process equipment. Locations of the condensate branch line connection into the main condensate headers. Insulation techniques An important factor to increase overall steam system efficiency is to maximize the temperature of the returning condensate. This permits high thermal cycle efficiency for the overall steam system. Energy Condensate contains a relatively large percentage 16 percent in some cases, depending on pressure of the energy used to produce the steam. The condensate should be maintained in a high-energy state or simply as hot as possible. A typical reason for condensate loss in the system is due to condensate component failure. In this paper, we will address the major reasons for component failure and provide recommendations on achieving energy savings with a properly operating condensate system. However, it is a recommended practice to apply these standards to all condensate systems. Maintenance A reasonable specification for condensate system design is to provide a reliable and long operational life span of more than 20 years without a primary condensate system failure. Plant personnel must assume that the condensate system designs shall include reasonable maintenance and plant services. Forgoing a proactive maintenance plan will reduce the anticipated lifespan of the condensate system. Materials Because condensate pipelines are potentially subjected to carbonic acid, a damaging corrosive element, material selection is important. The recommended material to use for a condensate system is stainless steel. However, understanding the cost limitations to an all stainless steel condensate system, other alternatives are available. If carbon steel piping is used for economical consideration, schedule 80 pipe is used because of the heavier wall thickness, which prolongs the life of the pipe in a corrosive environment. Connection Types Welding the condensate pipe or using tubing with tube connectors will minimize leaks. Condensate pipe will expand and contract during normal thermal cycling of a steam system operation. Unfortunately; steam component manufacturers still provide a large number of components with threaded NPT connections. The most common condensate piping connections are listed below in order of preference: Welded joints Tube material with tube connectors Flanges Threaded pipe only when necessary Pipe vs. Tubing Tubing is an acceptable method of piping, yet it is typically underutilized. Tubing provides an improved connection of steam components and other devices in the system. Welding smaller pipe sizes below 1 in. Using tubing material reduces the number of welds needed in an installation. Maintainability Most mechanical systems operate at peak performance levels following a new installation. However, system maintainability really determines the resiliency and reliability of the system. Frankly, if the devices are not accessible by plant personnel, there will be little or no maintenance performed and the overall system integrity will deteriorate. Although condensate is hot water, sizing a condensate line as if it were hot water would result in an undersized line. Undersized condensate lines will create excessive backpressure in the system, as well as maintenance and process problems throughout the system. The key item to remember is that there are two major differences between condensate and hot water. Condensate lines will contain two phases, condensate liquid and flash steam gas. Therefore, the correct size of a condensate line is somewhere between a hot water line and a steam line. With proper knowledge, a condensate line may be sized for the following: Condensate liquid load Flash steam load Neglect factor This is defined as steam loss resulting from faulty steam traps or open bypass valves. This is more common in systems than typically acknowledged. Blow-by steam will add steam flow to the return line and must be included in the calculations. Condensate that is free of flash steam may be pumped and sized as liquid only single phase flow. Condensate pipe velocities liquid and flash steam must be lower than feet per minute to prevent system waterhammer and other damaging effects. Condensate piping velocities liquid only must be lower than 7 feet per second. Correct Identification of Condensate Type The placement of condensate return lines is crucial to insure proper operation of the process equipment. The first step is to understand and identify the type of the condensate line. Gravity This describes all process equipment with a modulating inlet steam valve and a very low steam pressure application where the condensate return line must be at or close to atmospheric conditions. Therefore, the condensate drains by gravity to a vented atmospheric condensate collection tank. Low pressure return Condensate return that is less than 15 psi. Medium pressure Condensate return that is between 15 and psi. High pressure return Condensate return piping system pressures of psi or higher Most of the condensate system problems are from the location of the condensate lines in relationship to the heat transfer equipment, steam trap, and other drainage type devices. Connecting into the Condensate Header It is imperative that all condensate branch lines are connected into the top dead center of the main condensate header on a horizontal plane. This cannot be overstated and there is no exception to this rule. Improper condensate connections are listed below: Connection to the bottom of a condensate header. Connection to the side of a condensate header. Connection to a vertical condensate header. The condensate connections listed above will cause system problems, primarily waterhammer. Flash steam introduced to the main condensate header due to an improper connection location will interact with cooler condensate causing waterhammer. Pressure Gauges Finally, a note regarding pressure gauges. These devices, when properly installed in the condensate return system, are a great advantage to assisting in identifying the process and steam system malfunctions. If pressure gauges are not installed, always put the necessary taps in the system for a pressure gauge. This will allow maintenance personnel to install a gauge during troubleshooting procedures. It is necessary to include a siphon pipe pigtail and isolation valve with each pressure gauge. The isolation valve must be rated for the pressure and temperature of the operating system. Additionally, a liquid filled pressure gauge will be more resilient to system vibrations. Conclusion Condensate contains a high percentage of the energy typically 16 percent used to produce steam. Recovery and return of all possible condensate back to the boiler plant is the best method for cost containment and improved energy efficiency. Recover and return all possible condensate back to the boiler plant as hot as possible. Accept no component failure within three years of operation. Install components with maintenance in mind. Size condensate lines understanding the medium will be two phase flow. Utilize connections that minimize leaks. Understand the various pressures of condensate returns available in order to design the piping system with proper flow. Remember to allow for pressure gauge installations throughout the system. These inexpensive devices are a key aid in troubleshooting the steam and condensate system. Following these rules will help to ensure a reliable and long life span of the condensate system. For more information, visit www. Kelly is a recognized authority in steam and condensate systems. In addition, Kelly has published many papers on the topics of steam system design and operation. Over the past 30 years, he has conducted thousands of steam system audits and training sessions in the United States and overseas, which has made Kelly an expert in trouble-shooting actual and potential problems in the utilities of steam. Kelly is a member of the U.

Chapter 3 : Steam Power Plant Piping System

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The saddle to shell cracking was attributed to restrained axial thermal expansion of the shell at a tightly bolted sliding saddle support. The crack was ground out, welded and the support modified to permit sliding. The head to shell crack cause was attributed to corrosion fatigue, a common occurrence in deaerators. The crack was most likely initiated at a weld surface defect on the I. The daily operating cycles of the drum during periods of reduced steam demand and thermal stresses which we attributed to a poorly designed steam inlet nozzle were the main contributors to the crack growth. The steam exited through a rectangular shaped slot opening on the underside of the pipe which directed the flow of superheated steam directly into the condensate on the bottom of the drum near the shell-to-head weld. The superheated steam contact with the cooler condensate resulted in a violent reaction with localized heating and cooling of the vessel shell. This cycling can cause thermal stresses which can result fatigue cracking. Generally, fatigue cracking occurs at welds and heat affected zones adjacent to the weld. Notably no such weld cracking occurred at â€¦ Read More Soil-Structure Interaction Analysis of Buried Tanks Becht Engineering is performing a seismic analysis to assess the structural integrity of the tanks subjected to a postulated earthquake. The motivation for performing the soil-structure interaction SSI analysis in the time domain is to capture the behavior of several contact interfaces present in the tanks including the interface between the tank concrete and the surrounding soil. The presence of this contact interface helps to establish a realistic initial geostatic stress state under gravity loading. Before the SSI analysis was conducted, a site-response analysis was performed to determine the strain-compatible soil properties. Boundary conditions on the model were prescribed to enforce shear beam behavior of the soil column surrounding and supporting the tank. The seismic input was applied at the base of the SSI model as a force time series corresponding to the known acceleration record. The model includes the tank waste and the effects of concrete degradation as illustrated below. The soil and concrete are modeled using linear elastic material properties with concrete degradation simulated through the use of equivalent degraded elastic properties. When linear elastic material properties are used to model soils, there is potential for developing artificial soil arching. Excessive arching behavior will result in underestimating the vertical loads on the concrete dome and tank sidewalls. To mitigate the potential for soil arching above the dome, vertical contact surfaces are inserted into the soil above the dome to create annular rings of soil that are free to displace vertically consistent with the tank dome, but allow the load to be transferred laterally during horizontal motion. This effectively creates a nonlinear yield mechanism that acts in the vertical direction only and allows for horizontal load transfer from one ring to the other ring. Uncontrolled reverse flow in the system can occur and if improperly selected check valves are used it can result in pumps running backwards or transient pressure spikes in the system, i. Water hammer will occur if reverse flow occurs prior closure of the check valve and the effect increases with higher reverse flow velocity. Becht has worked with clients on analysis of the design of their systems, e. In a three pump system two operating and one spare , one and two pump trips were analyzed to determine the response of the system, i. The figure shows the forward fluid velocity vs. Based on the analysis, the required performance of the check valve to minimize reverse flow can be determined and a valve selected. No valve will close precisely at "zero" fluid velocity; however, certain type valves perform significantly better than others. A trapped gas pocket in a liquid system can occur in several configurations, as illustrated in Figure 1. In an effort to better show the effects of different modeling methods, this paper willâ€¦ Read More 1.

Chapter 4 : Proper Sizing of Steam Header Drains Prevents Water Induction

PROCESS PLANT PIPING SYSTEM DESIGN By: steam, air, and water P = Design pressure, psig D = Pipe outside *diameter, in.*

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Steam Piping Its Economical Design and Correct Layout by A. Langstaff Johnston The Transportation of Gases, Liquids and Solids by Means of Steam, Compressed Air and Pressure Water A Complete Description of the Theory, Construction, Operation and Application of Jet Machines, Spray Nozzles, Etc;, For Chemical, Metallurgical, Mining, Mechanical.

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2. High-Pressure Piping Systems Power plant typesPower plant types Water/steam cycles in thermal powerWater/steam cycles in thermal power plants are the connections between.

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The code covers boiler external piping for power boilers and high temperature, high pressure water boilers in which steam or vapor is generated at a pressure of more than 15 PSIG; and high temperature water is generated at pressures exceeding PSIG and/or temperatures exceeding degrees F.

Chapter 9 : Steam Engineering Tutorials

SteamPlantâ„¢ process design software allows you to perform spreadsheet analysis of steam power plant equipment, entire steam power plants, and many other aqueous processes using the highly accurate IFC equation of state for water.