System Design, Specifications, Operation, and Ir Deaerators

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Deaerator cracking can be controlled by periodic inspection and repair of operating units.

Introduction

Catastrophic failure of deaerator pressure vessel welds has included incidents that resulted in plan Failures originated as cracks caused by residual, thermal, static, and dynamic stresses, with growtl by corrosion fatigue. Weld deformities and hardened material in the heat-affected zone of welds fu failures. In some instances shell cracking has resulted in small leaks; in others, complete failure ha the life-taking and life-threatening failures reported in 1982 and 1983, technical advisories and gu outlining the necessity of internal weld inspection and recommending methods for inspection and statements of this type were issued by TAPPI, the National Association of Corrosion Engineers (N

Board of Boiler and Pressure Vessel Inspectors. TAPPI and NACE formed advisory groups to add
The TAPPI group is an ad hoc committee of the Steam and Power Committee. NACE established
Deaerator Cracking, to study and compile information on the subject. The summary of the TAPPI
presented here.

Pressure vessel weld cracks

A large number of deaerators have now been inspected. Cracking has been more prevalent than fi
30 - 50 percent of all industrial deaerators that have been inspected. Cracks have appeared in circu
longitudinal weld seams of both the heater and storage vessels. Circumferential seams are suscepti
longitudinal seams, with the highest incidence occurring in the 'T' junction of the two seams. Crac
randomly at different service nozzle welds affected by thermal expansion and thermal shock.

Cracks are thought to be caused by residual stresses imposed during manufacture, along with ther
and stress loads imposed during uneven deaerator operation. New evidence suggests that some cra
area of pits caused by corrosion. Once cracks begin, they are stressed open during periods of oper
to collect on newly fractured surfaces, which causes corrosion fatigue. The slightly hardened heat-
is where most cracks occur. Therein lies the whole problem corrosion and weld discontinuities fol
corrosion fatigue along the heat-affected zone of the welded joint.

Inspection and repair

Inspection and repair is the tool for the control of the growth of cracks. All deaerators, including t
ASME constructed and those designated as non-ASME constructed, should be periodically inspec
inspection supervision, should be conducted by a certified ASNT SNT-TC-1A Level II inspector.
put into service, it should be inspected within one to two years. After that, the following frequency
suggested at the NACE 1986 conference:

- Repaired cracks, 1 year or less
- Nonrepaired cracks, 1 - 2 years
- No cracks/no repairs, 3 - 5 years

Repaired vessels, at the same operating conditions, tend to recrack faster than the original vessel. I
should be more frequent after repairs.

Type of examination	**Explanation**
Spot	One X-ray shot in every 50 ft of weld, at a circumferential and longitudinal junction.
Postal	Two X-ray shots in every 50 ft of weld. one at a circumferenti and longitudinal Junction and one at random.
100%	One X-ray shot per ft of weld seam.

The tank in which these estimates are based is 8 ft in diameter and 20 ft long. Th of weld in three circumferential welds, and two longitudinal welds.

Table 1. Example of estimated costs for x-ray examination.

A major part of any inspection program is planning and preparation. The downtime for inspection
by reducing unforeseen delays. Preparation should include several important steps. First, a data fil
each deaerator, including system design drawings, tank modification records, histories of inspectic
or sketches showing areas of cracks and repairs, and ASME Manufacturer's Data Reports. Second,

should be conducted with the owner, the insurance inspector (an authorized inspector who holds a Commission), and qualified inspection and repair team representatives. A schedule for each task, i cool time, should be prepared.

The inspection of internal tank and weld seams should include circumferential, longitudinal, nozzl by residual and operating stresses. The actual nondestructive examination should be in accordance and NACE guidelines and must be conducted from inside the vessels. Each weld should be prepar the following steps:

1. Clean the weld to the base metal (brush, wipe down, etc.).

2. Inspect visually, especially at the intersections of circumferential and longitudinal seams.

3. Test by the wet fluorescent magnetic particle (WFMP) procedure over the entire weld, in "

4. If cracks are found, grind approximately 20 percent of each weld having cracks flush to the with WFMP.

5. If cracks are found after retesting with WFMP, they must be ground out. Cracks then shou I, in which the depth of the crack does not exceed the corrosion allowance, (b) Class II, in the corrosion allowance but not the minimum design thickness, or (c) Class III, in which th minimum design thickness.

6. It is mandatory to repair Class II cracks. Repairs must conform to the original design, and acceptable to the authorized (insurance company) inspector.[b] The repair paperwork should records of the vessel.

7. Summarize the inspection and repair results in the data file for each deaerator.

New units-construction improvement

The deaerator specification is the most important tool available to improve the constructio reducing stress and corrosion causes of cracking. The areas of concern are weld joints and attachm

- Quality of the weld
- Residual stresses of manufacture
- Thermal shock or stress
- Dynamic loads imposed by operation
- Corrosion.

The quality of welds

An important means of reducing corrosion and stress in weld seams is to ensure that the original w best way to check weld quality is by X-ray examination. While the cost of X-ray examination will another and from one manufacturer to another, the inspection adds a little to the cost of the deaera for varying degrees of X-ray examination is shown in Table I. Based on the relatively small cost, i partial X-ray examinations[c] be specified as a minimum for new deaerators.

Residual stresses of manufacture

Cuts of parent metal at weld junctions should be smooth with no torch cuts allowed.

Removal of residual stresses of manufacture is recommended through post-weld heat treatment (P
1100- 1200oF for a time based on plate thickness as recommended by the ASME Code. If internal
to the point of reducing their corrosion resistance, they should be removed. It will be necessary to
heater vessel to do this when the head is welded to the vessel, a local PWHT which extends 360° I
of the vessel must be applied to this last circumferential weld.

Thermal stress and shock loads

Internal components must not impart stress loads to the pressure vessel as a result of differences ir
temperature should be uniform over the entire vessel. Cold spots should be avoided. Avoid nozzle
by temperature cycles. Sleeves are an alternative. The deaerator should be specified to accommod
moments imposed by piping on all connections.

Dynamic loads of operation

The major forces imposed on a deaerator are caused by pressure changes in a short, limited time. I
should be used between the heating vessel and the storage vessel, designed to avoid additional stre
nozzles.

Specify the manholes be reinforced to distribute load at the shell weld area. Reinforce relief valve
valve thrust load at the weld no matter which direction the valve is mounted.

Consider a third fixed center support for long, small-diameter vessels to reduce thermal expansion
longitudinal direction. This support will also support the load of the centrally mounted heating ves
deflection in the storage vessel shell.

Deaerator pressure vessels should have the same design pressure as the header pressure of the stea
prevent over-pressure during the steam pressure reducing valve failure in the open position.

Corrosion

Corrosion must be eliminated to the greatest possible extent. Specify a minimum of 1/16-in. corro
full vacuum to eliminate vacuum breakers, which allow oxygen to be drawn into vessels during sv
Specify that spray devices be in a vertical position and that they be mounted on a flat surface to pr

Internal tray packing and piping devices should be securely fastened so as not to become dislodge
piping between tanks should be covered by baffles to prevent tray and internal damage during pres

Primer paint should be required on the exterior of vessels. Nozzles should be factory sealed with d
to prevent internal corrosion during shipment and storage.

System design

The deaerator system should be designed to maintain a constant operating pressure and temperatu
through all operating ranges. Several design suggestions should be considered.

First, install a pressure-reducing valve in the steam line that feeds the deaerator, with its sensing li
itself. The pressure-reducing valve should be near the deaerator (Fig. 1).

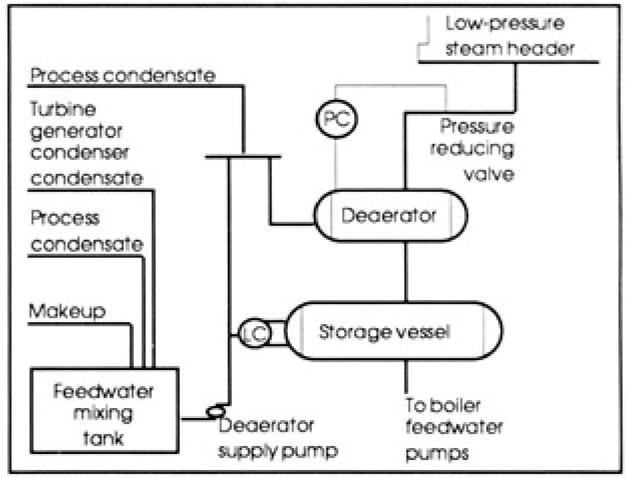

Fig. 1. Flow scheme showing the feedwater mixing tank and the steam pressure-reducing valve.

Second, condensates and makeup water should be blended before the deaerator heater. This blendi header just ahead of the deaerator or in a feedwater mixing tank between the demineralizers and d eliminates the temperature differential between separate makeup water and condensate connection feedwater mixing tank has the added advantage of making temperature changes more gradual whe vary. The choice should be evaluated based on the relative flows of hot condensate and makeup w history of condensate flow interruptions.

Third, reduce stress on piping connections. Piping design should ensure that actual forces and mor specified. Steam supply piping should be sloped for condensate to drain to the deaerator.

Fourth, oxygen scavenger should be added in the downcomer between the heater and the storage v

Operation

Before operators are assigned to any power plant system, they must understand the intended opera is as true for the deaerator as it is for any other part of the power plant. The deaerator should alwa by the system designer.

Under normal operating conditions, the deaerator heats water as expected and removes oxygen to concentration. In the past, because they have worked so well, deaerators have received little attent removal was less efficient than required, the quantity of oxygen scavenger was simply increased t and temperature fluctuations have been considered as normal operating conditions. With the incre system design, a corresponding attention to improved operation must follow. The operator should monitor all operating data. When any condition fluctuates beyond acceptable limits, especially ten causes should be found and corrected. Even though abnormal operation of the deaerator may not r immediate danger as a low drum level or a safety valve blowing the long-term effect, if not correc catastrophic.

Some abnormal conditions that should be avoided through close operator attention include (a) rest especially with cold feedwater, (b) operation above maximum capacity, (c) operation below minin operating with blended water temperature too high, (e) any significant pressure or temperature flu and (g) high oxygen in the boiler feedwater from the deaerator.

Conclusion

Deaerator cracking has been found to be widespread, and it has the potential for causing catastrop can be controlled, however, by periodic inspection and repair of operating units. Good engineerin specification and design of new deaerators and in the systems in which they operate can eliminate could cause cracks to begin and grow. Proper operation of the deaerator is a continuing requireme failure.

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[a] The law of the jurisdiction where the vessel is located may require more frequent inspections.

[b] The repairs should be completed according to the requirements of the National Board Inspection Chapter III Repairs and Alteration. To assure the total integrity, an organization holding a Nationa Authorization and the "R" symbol stamp should be used.

[c] For clarification, the ASME Code, Section VIII, Division 1 did address a condition of "partial ra deleted and now Section VIII, Division 1 addresses only spot or full radiography.

Editor's note: The following article is reprinted from the April 1988 National Some *ASME Boiler and Pressure Vessel Code* requirements may have change advances in material technology and/or actual experience. The reader is caut latest edition and addenda of the *ASME Boiler and Pressure Vessel Code* for c requirements.

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