"PMCap" Local Thin Area Repair and Restoration Component for Pressure Retaining Items[(U.S. Patent 6,860,297)]

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ABSTRACT

A common method of pressure boundary repair for localized metal loss involves cutting out the affected section and replacing it with new material of equivalent or better erosion/corrosion resistance. New sections are installed using full penetration welds. This type of repair is generally referred to as a "flush patch repair".

A "weld build-up" repair can also be performed to restore areas of localized metal loss. In this type of repair, weld metal is deposited on the thin area to restore the profile and thickness to original supplied condition.

Other types of repairs occasionally considered include metal build-up on the outer pressure boundary surface using weld overlay or installation of a "patch plate" overlay. In the "patch plate" repair, a new plate is fillet welded to the outer surface of the pressure boundary on top of the thin area. However, the National Board Inspection Code (NBIC), which most jurisdictional authorities in the United States follow, does not allow weld overlay on the outer pressure boundary surface or "patch plate" type repairs.

PMC Engineering Solutions, Inc. has developed an alternative repair method that is applied externally, satisfies code requirements, and is acceptable to local jurisdictions. This alternate repair uses a custom designed repair component that encapsulates defective pressure boundaries. The repair component is entitled "**Local Thin Area Repair and Restoration Component for Pressure Retaining Items [(U.S. Patent 8,860,297) "**, and is hereinafter referred to as the "PMCap".

BACKGROUND

The "flush patch" and cavity "weld build-up" repair methods are allowed by the National Board Inspection Code (NBIC) and are accepted by jurisdictional authorities. The "flush patch" repair involves removal of degraded vessel wall and replacement with new material. The "weld build-up" repair method restores wall profile and thickness to original supplied condition by depositing weld metal to a local thin area. These material replacement repair methods can provide a factor of safety

and erosion/corrosion protection equal to original construction. To maintain the original design factor of safety, nondestructive examination of the new weld, using the same or equivalent NDE method as that used during original construction, is required. For most pressure vessel repairs, ultrasonic examination of the new welds is performed as an alternative to the radiographic examination originally specified. Additionally, the jurisdictional authority may require a hydrostatic test of the vessel after completion of the repair.

Material replacement repair methods have several other limitations including:

1. Requires removal and isolation of vessel from service.
2. Requires removal of defective vessel wall.
3. Creates personnel risk of exposure to hazardous vessel contents.
4. Creates environmental risks associated with disposal of vessel contents and job materials.
5. Creates risk of damage to vessel internals.
6. Creates risk of foreign material intrusion.
7. Requires cutting vessel wall for new "flush patch".
8. Requires exact fit-up of new flush patch replacement plate into vessel cutout with edge weld joint preparation.
9. May require use of weld joint backing strips to achieve full penetration weld. Note: *Backing strips left in place may result in a reduction in weld joint efficiency factor. Also, in high flow regions, backing strips may separate and become loose parts or create new flow turbulence thus accelerates local erosion.*
10. Requires welder access inside vessel for "weld build-up" repair.
11. May expose welder to radiological hazards.
12. Requires equipment downtime to implement repairs.
13. Labor and time intensive repair.

ALTERNATIVE REPAIR METHOD

PMC Engineering Solutions, Inc. has developed an alternative repair method that satisfies code requirements and is acceptable to local jurisdictions without the limitations identified above. This alternate repair uses a custom designed repair component that encapsulates defective pressure boundaries. The repair component is entitled "**Local Thin Area Repair and Restoration Component for Pressure Retaining Items** (U.S. Patent 8,860,297) ", and is hereinafter referred to as the "PMCap".

The "PMCap" is a pre-fabricated component used to repair pressure boundaries with local thin areas, cracks or pitting. It is welded onto the outside pressure boundary surface using a full penetration weld and becomes an extension to the pressure boundary.

Repairs can be made without removing defects. Degraded wall areas are totally encapsulated by the "PMCap" which is designed to provide all required structural, pressure integrity, and local area reinforcement. "PMCap"s allow for quick repairs and rapid return to service with minimal risk by eliminating cutting of the pressure boundary, foreign matter intrusion, and exposing vessel internals or contents to the environment.

The "PMCap" is designed and fabricated to meet original design and appropriate jurisdictional code requirements. They can be designed to encapsulate shell, head, or nozzle regions in any shape but are commonly supplied as round or obround. The "PMCap" can be used to repair pressure boundaries in pressure vessels, piping, and tanks. They will restore the structural, pressure retaining integrity, and erosion/corrosion capability to an original or enhanced design condition. "PMCap's include a corrosion allowance adequate for the remaining item life or can be supplied with an optional corrosion resistant liner.

Design

"PMCap"s can be designed to various codes or standards. Primarily, the ASME Section III, or VIII, Division 1 code is used for components that will be us to repair vessels originally constructed to the ASME code. Details on designing a "PMCap" for compliance with the ASME VIII, Div. 1 code are provide below.

"PMCap"s are designed for vessel internal and external design pressures, including pressurization of the cavity should the encapsulated wall be breeched. These loadings cause both membrane and bending stresses in the skirt and flat head portion of the "PMCap". The "PMCap" is designed to satisfy these loadings per ASME code rules and stress acceptance criteria. Thickness determination is based on design pressure and area replacement criteria. As a minimum, code criteria, contained in Sections UG-27, "Thickness of Shells Under Internal Pressure", UG-28, "Thickness of Shells Under External Pressure", UG-34, Unstayed Flat Heads and Covers, and Appendix 13, Vessels of noncircular Cross Section are followed as applicable. Additionally, Code rules contained in Appendix 1, Supplementary Design Formulas, and Appendix 14, Integral Flat heads with a Large, Single, Circular, Centrally Located Opening, as applicable, are considered.

The "PMCap" is designed to integrally reinforce the shell to improve structural and pressure retention integrity. Code rules contained in Section UG-37, Reinforcement Required for Openings in Shells and Formed Heads, are followed to determine the thickness of the flat head portion of the "PMCap" required for reinforcement of the local thin area. Generally, vessel wall encapsulated by the "PMCap" is not included in strength or reinforcement design. However, this wall provides an erosion/corrosion barrier that may be used in determining remaining service life.

Corrosion allowances for remaining design life are calculated and added to thickness requirements governed by code stress and reinforcement rules. Alternatively, the "PMCap" can be provided with an erosion/corrosion resistant liner. No strength or reinforcement credit is taken for the encapsulated area or material provided solely for erosion/corrosion protection. Vessels, which have been repaired with "PMCap" s, meet or exceed original design and have improved erosion/corrosion resistance at the repaired location.

Fabrication

The PMCap is usually round but can be square, rectangular, obround, oval,

triangular, or any combination of these shapes. They can be constructed to various codes and standards but are generally constructed in compliance with ASME code requirements. Fabrication discussions provide herein are based on ASME code construction. "PMCap"s are fabricated from a single piece of material or by welding composite pieces. They are rolled, machined, formed, forged, or cast to fit the contour of the outer surface of the pressure boundary they are to be attached to. All internal machined radii are designed to reduce stress concentrations if the cavity is pressurized during operation. The reinforcement plate head weld can be shop pressure tested for fabricated "PMCap"s. "PMCap"s can be supplied as either ASME code "material" or ASME code-stamped "U" or "N" components. They can be pre-staged for future repairs and rolled to fit prior to installation. An "PMCap" package includes hardware, material certifications, examination and test reports, partial data reports, shop fabrication drawings, and certified calculations. A detail of an installed "PMCap" cross section is shown in Figure 1".

Installation

The "PMCap" is attached by a full penetration weld to the pressure boundary outer surface. The internal cavity between the pressure boundary surface and the inner surface of the "PMCap" allows for volumetric examination of the attachment weld. If pressure testing of the attachment weld is required, the "PMCap" can be supplied with pressure taps for use in pressurizing the cavity (note: the encapsulated area thickness will need to support hydrostatic testing as well). Alternatively, a small hole can be drilled into the existing pressure boundary for complete vessel hydro and in-service pressure testing..

DESIGN OBJECTIVES AND ADVANTAGES OVER CURRENT REPAIR METHODS

The objectives in designing the "PMCap" were to provide a simple, safe, cost effective method of repairing pressure boundaries in compliance with original design codes. An additional design objective was to provide a repair method that alleviated or eliminated many if not all of the negative aspects of the current common methods of repair using the "flush patch " or "weld build-up" type repairs. Various national codes, including but not limited to, the American Society of Mechanical Engineers (ASME), American National Standards Institute (ANSI), Tubular Exchanger Manufacturers Association (TEMA), American Petroleum Institute (API), and National Board Inspection Code (NBIC) govern construction, operation, and in-service inspection. Local jurisdictional authorities may specify combinations of these governing codes for construction, operation, and inspection.

The "PMCap" solves many of the negative aspects of current common methods of repair and offers several advantages. These include but are not limited to:

1. May not require removal of the pressure retaining item from service.
2. Does not require removal of defective section from vessel wall.

3. Does not require vessel shell preparation for "PMCap" weld attachment.
4. Does not require weld joint backing strips.
5. Eliminates risk of personnel exposure to lethal or hazardous vessel contents.
6. Eliminates environmental risks associated with release of contents.
7. Eliminates risk of damage to vessel internals.
8. Eliminates risk of intrusion of foreign materials.
9. Eliminates need to breech pressure boundary for repairs.
10. Eliminates need for personnel to access inside of vessel.
11. Eliminates contaminated material disposal costs.
12. Allows for hydrostatic or pneumatic testing after repairs.
13. No geometric shape limitations.
14. Quick and simple to install thus reducing costs associated with repair or equipment downtime.

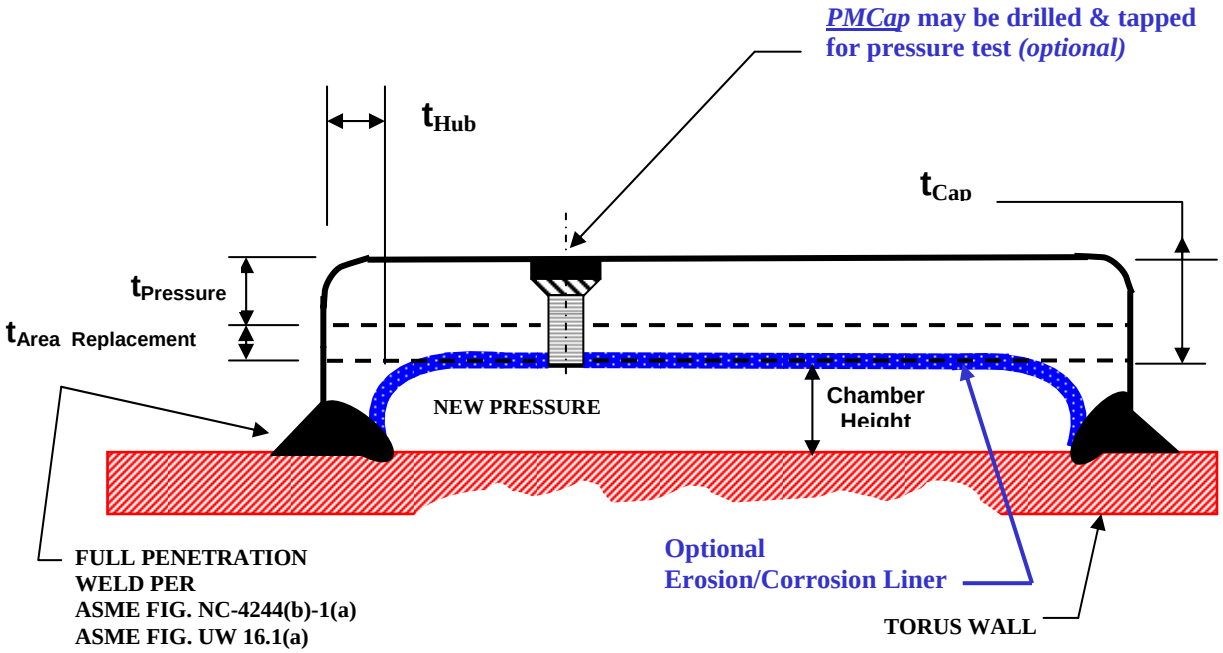

Figure 1