Technical Report on the Materials and Fabrication Issues of 1 1/4Cr-1/2Mo and 1Cr-1/2Mo Steel Pressure Vessels

API TECHNICAL REPORT 934-D
FIRST EDITION, SEPTEMBER 2010

AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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Introduction

Numerous $1^1/_4$Cr-$^1/_2$Mo and 1Cr-$^1/_2$Mo vessels have been constructed and successfully used in various applications in petroleum industry and in other types of service applications. These vessels have been constructed to the requirements of the *ASME Boiler & Pressure Vessel Code*, Section VIII, Divisions 1 and 2, and to various international pressure vessel codes and standards. The $1^1/_4$Cr-$^1/_2$Mo and 1Cr-$^1/_2$Mo vessels are typically used in service conditions (e.g. high temperature and/or high pressure hydrogen), which require heavy walls and cause in service deterioration. As such, the steels are subject to special requirements, such as notch toughness, elevated temperature tensile properties, hardness, fabrication heat treatments, etc., which may limit the maximum thickness to be able to meet the desired properties. Corrosion protection by stainless steel weld overlay or cladding may also be required. It is important to know the limitations of these materials and precautions needed to avoid problems during fabrication and to eliminate or minimize in service deterioration. To better understand the current practices in fabricating $1^1/_4$Cr-$^1/_2$Mo and 1Cr-$^1/_2$Mo steels a questionnaire was distributed to steel fabricators as part of this study. Responses to this questionnaire have been used in this study and are summarized in Appendix 1.

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1 Scope

This API document provides background information and guidance on the implementation of API 934-C, *Materials and Fabrication of 1 1/4Cr-1/2Mo Steel Heavy Wall Pressure Vessels for High Pressure Hydrogen Service Operating at Temperatures at or Below 825 °F (426 °C)* and API RP 934E, *Materials and Fabrication of 1 1/4Cr-1/2Mo Steel Heavy Wall Pressure Vessels for High Temperature Service Operating Above 825 °F (426 °C)*, and should be used as a supplement to these recommended practices.

In recent years it has been recognized that there are important distinctions that need to be considered for 1 1/4/1Cr-1/2Mo steels. Whereas API 934-A continues to provide materials and fabrication requirements for new 2 1/4/3Cr-1Mo and 2 1/4/3Cr-1Mo-1/4V steel heavy wall pressure vessels in high temperature, high pressure hydrogen service, different material, and fabrication requirements have been developed for 1 1/4/1Cr-1/2Mo steel heavy wall pressure vessels. These requirements are covered in RP 934-C and 934-E.

This document contains a description of key damage mechanisms that relate specifically to 1 1/4/1Cr-1/2Mo pressure vessels used in a variety of services. These damage mechanisms include elevated temperature damage mechanisms such as “reheat cracking” or “creep embrittlement” as well as other damage mechanisms that may occur at lower temperatures. Not all services are affected by the same damage mechanisms due to significant differences in service conditions. For example, Hydrofiner Reactors tend to operate at lower temperatures and higher pressures than Catalytic Reformer Reactors, and Coke Drums and FCC Reactors do not see hydrogen service. Also, as a result of the different services causing different damage mechanisms, the fabrication requirements also differ. To this end, API has developed two separate recommended practices to take this into account: API 934-C and 934-E. Accordingly, background information and guidance on the implementation of these two new documents are needed.

This document provides information and guidance on successful practices for fabrication of 1 1/4/1Cr-1/2Mo steel heavy wall pressure vessels for the intended services of both API 934-C and 934-E. The survey of steel producers and vessel fabricators (Annex 1) indicates that there is a need to evaluate the effect of heat treat cycles on materials properties (CVN toughness, tensile and yield strength). For this reason the connection of the Larson-Miller parameter is emphasized to better align the user needs with fabrication requirements. However, detailed attention is still needed to implement this approach for individual cases, as there are many secondary variables, such as heating and cooling rates that need to be considered and discussed between the user and the fabricator. The areas of fabrication that are covered in this document include steel making as related to chemical composition, heat treatment, forming, and welding.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 934-A, *Materials and Fabrication of 2 1/4Cr-1Mo/1/4 V, 3Cr-1Mo and 3Cr-1Mo/1/4V Steel Heavy Wall Pressure Vessels for High Temperature High Pressure Service*

API Recommended Practice 934-C, *Materials and Fabrication of 1 1/4Cr-1Mo Steel Heavy Wall Pressure Vessels for High Pressure Hydrogen Service Operating at or Below 825 °F (440 °C)*

API Recommended Practice 934-E, *Recommended Practice for Materials and Fabrication of 1 1/4Cr-1Mo Steel Pressure Vessels for Service Above 825 °F (440 °C)*