

# Technical Report on the Materials and Fabrication Issues of 1<sup>1</sup>/<sub>4</sub>Cr-1<sup>1</sup>/<sub>2</sub>Mo and 1Cr-1<sup>1</sup>/<sub>2</sub>Mo 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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## Contents

	Page
1 Scope .....	1
2 Normative References .....	1
3 Terms, Definitions, and Acronyms .....	2
3.1 Definitions .....	2
3.2 Acronyms .....	3
4 Background .....	3
4.1 1 <sup>1/4</sup> /1Cr-1/2Mo Refinery Equipment .....	3
4.2 Past In-Service Cracking and Toughness Problems with 1 <sup>1/4</sup> /1Cr-1/2Mo Steels .....	4
5 General Considerations .....	6
5.1 1 <sup>1/4</sup> /1Cr-1/2Mo Product Specifications and Properties .....	6
5.2 Allowable Design Stresses .....	6
5.3 Steel Making Practices and Processing .....	9
5.4 Hardenability Limitations that Affect Mid-Wall Tensile Properties and Notch Toughness10	10
6 Mechanical Properties .....	10
6.1 The Effect of Heat Treatment, Including Post-weld Heat Treatment (PWHT) on Tensile Strength and Yield Strength of 1Cr-1/2Mo and 1 <sup>1/4</sup> Cr-1/2Mo Steels .....	10
6.2 The Effect of Thickness on Tensile Properties .....	12
6.3 The Effect of Chemical Composition on Tensile Properties .....	13
6.4 Notch Toughness .....	13
6.5 Forgings for 1 <sup>1/4</sup> /1Cr-1/2Mo Reactors .....	16
7 Embrittlement and Cracking Issues In 1 <sup>1/4</sup> /1Cr-1/2Mo Base Metals and Welded Joints .....	18
7.1 General .....	18
7.2 Temper Embrittlement .....	18
7.3 Stress Relief Embrittlement .....	19
7.4 Creep Embrittlement .....	19
8 Guidelines On Chemical Composition, Heat Treatment and Mechanical Testing of 1 <sup>1/4</sup> /1Cr-1/2Mo Vessels .....	21
8.1 Chemical Composition .....	21
8.2 Heat Treatment for All Applications .....	22
9 Testing of Plates and Forgings .....	24
9.1 Test Specimen Location to Simulate the Cooling Rates in Plates and Forgings .....	24
9.2 Test Coupons to Simulate Vessel Fabrication Heat Treatments .....	25
9.3 Test Specimen Location to Simulate the Cooling Rates in Plates and Forgings .....	25
9.4 Hot Tension Tests .....	25
10 Fabrication/Metal Forming .....	26
10.1 Forged Shell Rings vs. Shell Rings Made of Plate .....	26
10.2 Forming .....	27
10.3 Cold Forming .....	27
10.4 Warm Forming .....	29
10.5 Hot Forming .....	29
11 Fabrication/Welding .....	29

## Contents

	Page
11.1 Welding Processes for $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ and $1\text{Cr}-1\frac{1}{2}\text{Mo}$ Welding .....	29
11.2 Preheat and DHT to Avoid Cracking .....	30
11.3 ISR vs. DHT for $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ and $1\text{Cr}-1\frac{1}{2}\text{Mo}$ Materials .....	31
12 Austenitic Stainless Steel Cladding and Weld Overlay .....	33
12.1 Weld Overlay .....	33
12.2 Weld Overlay Procedure Qualifications .....	34
12.3 Preheat and Heat Treatments During Weld Overlay .....	34
12.4 Production Testing of Weld Overlay .....	35
12.5 Weld Overlay Disbonding .....	35
Annex A (informative) API 934-D Questionnaire on $1\text{Cr}-1\frac{1}{2}\text{Mo}$ and $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ Issue .....	37
Bibliography .....	55
<b>Figures</b>	
1 The Effect of Cooling Rate on Tensile Properties .....	11
2 The Effect of Post-weld Heat Treating Temperature on Tensile Properties of N&T A387, Gr. 11 Steel as a Function of Tempering Parameter (LMP) .....	12
3 Tensile Properties of Two A387 Gr. 11, Class 2 Plates, 3.2 in. (80 mm) and 5.6 in. (143 mm) Thick as a Function of Tempering Parameter (LMP) .....	13
4 The Effect of Stress Relief on Tensile Strength of A387 Gr. 12 and Gr. 22 Plates as a Function of Tempering Parameter (LMP) .....	14
5 The Effect of Carbon Equivalent on Tensile Properties as a Function of Tempering Parameter (LMP) ..	15
6 Graville Diagram Showing Relative Susceptibility of A387 Steels to HAZ Cracking During Welding. . .	16
7 The Effect of Postweld Heat Treatment on 40 ft-lb (54 J) Transition Temperature in N&T and Q&T A387, Gr. 11 Plates as a Function of Tempering Parameter (LMP) .....	17
8 Toughness Properties (Kv) of Two Plates A387 Gr. 11, Cl. 2, 3.15 in. (80 mm) and 5.63 in. (143 mm) Thick as a Function of Tempering Parameter .....	17
9 Transition Temperature Shift in $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ Plate Metal Due to Temper Embrittlement .....	19
10 40 ft-lb (54 J) Transition Temperature Shift and J-Factor in Low Phosphorus Cr-Mo Steels .....	20
11 HAZ Cracks from Creep Damage .....	20
12 The Role of Phosphorus in Creep Embrittlement and Cracking—Creep Rupture Elongation of A387 Gr. 11 at 500 °C .....	23
13 Results of Hot Tensile Tests from SA-387 Gr. 11 Plates After Heat Treatment to Tempering Parameter (LMP) of 20,400 in Terms of °C (36,700 in Terms of °F) .....	26
14 Temporary Attachment Welds Using Temper Bead Technique .....	31
15 Possible Embedded Hydrogen Crack Caused by Interrupting Preheat on Partially Welded Beam without Postheat .....	32
16 Weld Overlay Disbonding Tests on Cr-Mo Steels .....	36
<b>Table</b>	
1 Typical Refinery Vessels Using $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ Steels .....	4
2 Cracking Problems with $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ Steel .....	5
3 Cracking Experience with $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ Hot-Wall Reactors .....	5
4 Previous Literature/Data/Experience/Issues .....	6
5a ASME SA Specifications .....	7

## Contents

	Page
5b European Specification EN-10028-2:2003 .....	8
6 Allowable Design Stresses, for ASME Section VIII, Division 1 Vessels .....	9
7 Allowable Design Stresses, for ASME Section VIII, Division 2 Vessels (2004 Edition).....	9
8 Allowable Design Stresses, for ASME Section VIII, Division 2 Vessels (2010 Edition).....	9
9 Example of Requirements for SA-387 Gr. 11 Cl.2 and Possible Proposals. Plate Thickness: 6 in. (125 mm).....	24
10 Forming Temperature Ranges .....	27
11 Maximum Forming Strains without Heat Treatment .....	28
12 Welding Processes for 1 <sup>1/4</sup> /1Cr-1/2Mo Vessels .....	30
13 Preheat and Postheat Requirements .....	31

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## Introduction

Numerous  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  and  $1\text{Cr}-1\frac{1}{2}\text{Mo}$  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  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  and  $1\text{Cr}-1\frac{1}{2}\text{Mo}$  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  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  and  $1\text{Cr}-1\frac{1}{2}\text{Mo}$  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.



# Technical Report on the Materials and Fabrication Issues of $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$ and $1\text{Cr}-1\frac{1}{2}\text{Mo}$ Steel Pressure Vessels

## 1 Scope

This API document provides background information and guidance on the implementation of API 934-C, *Materials and Fabrication of  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  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  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  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  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  steels. Whereas API 934-A continues to provide materials and fabrication requirements for new  $2\frac{1}{4}\text{Cr}-1\text{Mo}$  and  $2\frac{1}{4}\text{Cr}-1\text{Mo}-\frac{1}{4}\text{V}$  steel heavy wall pressure vessels in high temperature, high pressure hydrogen service, different material, and fabrication requirements have been developed for  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  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  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  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  $1\frac{1}{4}\text{Cr}-1\frac{1}{2}\text{Mo}$  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  $2\frac{1}{4}\text{Cr}-1\text{Mo}/\frac{1}{4}\text{V}$ ,  $3\text{Cr}-1\text{Mo}$  and  $3\text{Cr}-1\text{Mo}/\frac{1}{4}\text{V}$  Steel Heavy Wall Pressure Vessels for High Temperature High Pressure Service*

API Recommended Practice 934-C, *Materials and Fabrication of  $1\frac{1}{4}\text{Cr}-1\text{Mo}$  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  $1\frac{1}{4}\text{Cr}-1\text{Mo}$  Steel Pressure Vessels for Service Above 825 °F (440 °C)*