

# EXTEND ALLOWABLE STRESS VALUES FOR ALLOY 800H



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# EXTEND ALLOWABLE STRESS VALUES FOR ALLOY 800H

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## TABLE OF CONTENTS

Foreword .....	vi
Abstract .....	vii
1 INTRODUCTION .....	1
2 THE DATABASES .....	2
2.1 The Assembly of the Database for Calculation of the $S_{Yl}$ and $S_U$ Values .....	2
2.2 The Assembly of the Database for Calculation of the $S_r$ , $S_t$ and $S_{mt}$ Values .....	3
3 ANALYSIS OF TENSILE DATA .....	6
3.1 Analysis of Yield and Ultimate Tensile Strength Data for Estimating the $S_{Yl}$ and $S_U$ Values .....	6
4 ANALYSIS OF STRESS-RUPTURE DATA .....	9
4.1 Analysis Stress-Rupture Data for Minimum Stress-to-Rupture, $S_r$ .....	9
5 ANALYSIS OF CREEP DATA .....	14
5.1 Analysis of Tensile Curves .....	14
5.2 Development of an Alternate Plasticity Model for Alloy 800H .....	15
5.3 Analysis of the Time to Initiate Tertiary Creep .....	19
6 RECOMMENDATIONS OF ALLOWABLE STRESS INTENSITY VALUES .....	28
6.1 Values for $S_{Yl}$ and $S_U$ .....	28
6.2 Values for $S_m$ .....	29
6.3 Values for $S_t$ .....	30
6.4 Values for $S_{mt}$ .....	33
6.5 Values for $S_r$ .....	36
7 DISCUSSION .....	39
8 SUMMARY AND RECOMMENDATIONS .....	40
References .....	41
Appendix 1 - Estimation of the Time to Tertiary Creep .....	44
Appendix 2 - Time-Temperature Parametric Analysis .....	48
Appendix 3 - Notes on the Hot Tensile Curve .....	51
Acknowledgments .....	57

### LIST OF TABLES

Table 1 - Comparison of Chemistries for Variants of Alloy 800 .....	2
Table 2 - Typical Minimum Stress-to-Rupture Values in MPa .....	12
Table 3 - Modulus Values for Alloy 800H .....	14
Table 4 - Summary of the Curve-Fitting Results .....	19
Table 5 - Fit of Three Time-Temperatures to Alloy 800H Stress-Rupture Data and Comparison of Predicted Average Rupture Strengths (ksi) for 100,000 h at 1650°F (900°C) .....	49

Table 6 - Fit of Three Time-Temperatures to Alloy 800H Tertiary Creep Data and Comparison of Predicted Average Strengths (ksi) for 100,000 h at 1650°F (900°C) .....	50
Table 7 - Coefficients for the GA Hot Tensile Equation .....	51
Table 8 - Values for the Coefficients in a New Hot Tensile Model for Alloy 800H and the Calculated Stress for 1% Strain .....	53
Table 9 - Coefficients for the Ramberg-Osgood Model for the Hot Tensile Curve .....	54

## LIST OF FIGURES

Figure 1 - Definition for the Components of Creep Used in ASME Section III, Subsection NH .....	3
Figure 2 - Various Shapes for Creep Curves Observed in Alloy 800H .....	5
Figure 3 - Coefficients and R-squared Values for Polynomial Fit to $R_Y$ and $R_T$ Customary Units .....	6
Figure 4 - Fit of the the Polynomial to the $R_{YI}$ Values for Alloy 800H .....	7
Figure 5 - Fit of the Polynomial to the $R_T$ Values for Alloy 800H .....	7
Figure 6 - Distribution of the Yield Strengths Relative to the $S_Y R_Y$ Trend Curve .....	8
Figure 7 - Distribution of Ultimate Tensile Strengths Relative to $S_T R_T$ .....	8
Figure 8 - Stress Versus the Larson-Miller Parameter for the Stress-Rupture of 106 Lots of Alloy 800H (Stress in MPa, Parameter Based on Temperature in °C) .....	10
Figure 9 - Residuals in Log Time Versus Temperature for Larson-Miller Parameter for the Stress-Rupture of Alloy 800H .....	10
Figure 10 - Histogram of Residuals in Log Time for the Fit of the Larson-Miller Parameter .....	11
Figure 11 - Cumulative Percent of Residuals in Log Time for the Fit of the Larson-Miller Parameter to Stress-Rupture Data for Alloy 800H .....	11
Figure 12 - Calculated Rupture Life Versus Observed Rupture Life for the Fit of the Larson-Miller Parameter to Stress-Rupture Data for Alloy 800H .....	12
Figure 13 - Minimum Stress-to-Rupture Versus Time for Alloy 800H .....	13
Figure 14 - Comparison of Minimum Stress-to-Rupture Values at 100,000 h for the Current ASME III-NH, the German Standard KTA-3221 and the New Analysis Reported Here... 13	13
Figure 15 - Modulus Data for Alloy 800H .....	15
Figure 16 - Comparison of Hot Tensile Curves for 1400°F (760°C) .....	17
Figure 17 - Calculated Hot Tensile Curves for Selected Temperatures (deg F) .....	17
Figure 18 - Stress Versus the Larson Miller Parameter for 1% Strain and a Parametric Constant, $C$ , of 21.21 .....	19
Figure 19 - Leyda-Rowe Plot for Classical Creep (left) and Tertiary-Type Creep (right) of Alloy 800H .....	20
Figure 20 - Larson Miller Parameter for Time to Initiate Tertiary Creep for Classical-Type .....	21
Figure 21 - Larson Miller Parameter for Time to Initiate Tertiary Creep for “Tertiary-Type” Creep .....	22
Figure 22 - Larson Miller Parameter for Time to Initiate Tertiary Creep for all Data .....	22

Figure 23 - Residuals in Log Time Versus Temperature for Larson-Miller Parameter for the Tertiary Creep of Alloy 800H Including Combined Classical and Tertiary-Type Data .... 23

Figure 24 - Histogram of Residuals in Log Time for the Fit of the Larson-Miller Parameter for the Tertiary Creep of Alloy 800H Including Combined Classical and Tertiary-Type Data .... 24

Figure 25 - Cumulative Percent of Residuals in Log Time for the Fit of the Larson-Miller Parameter to All Tertiary Creep Data for Alloy 800H ..... 24

Figure 26 - Calculated Time to Tertiary Creep vs. Observed Time to Tertiary for the Fit of the Larson-Miller Parameter to All Tertiary Creep Data for Alloy 800H..... 25

Figure 27 - Isothermal Curves for Tertiary Creep Covering 450 to 900°C in 50°C Increments ..... 25

Figure 28 - Isothermal Curves for Tertiary Creep Covering 850 to 1650°F in 100°F increments..... 26

Figure 29 - Stress Versus Time to Initiate Tertiary Creep at 1650°F and 900°C..... 26

Figure 30 - Stress Versus Time Rupture for Alloy 800H at 1650°F and 900°C..... 27

Figure 31 -  $S_t$  Versus Temperature ..... 30

Figure 32 -  $S_{mt}$  Versus Time ..... 33

Figure 33 - Minimum Stress-to-Rupture ..... 36

Figure 34 - Typical Plot of Creep Data Supplied by HAI for Alloy 800HT (1.7 ksi at 1800°F) ..... 44

Figure 35 - Examples of the Estimation of the Time to Tertiary Creep,  $t_3$ , for Tertiary-Type Creep Curves Plotted from the HAI Data for 1500 and 1600°F (816 and 871°C) ..... 45

Figure 36 - Examples of the Estimation of the Time to Tertiary Creep,  $t_3$ , for Tertiary-Type Creep Curves Plotted from the Petten Database ..... 46

Figure 37 - A Creep Curve for 1472°F (800°C) Extracted from a VAMAS Report Showing Sigmoidal Character ..... 47

Figure 38 - Examples of the Estimation of the Time to Tertiary Creep,  $t_3$ , for Tertiary-Type Creep Curves Plotted from the NUREP Data for 1650°F (900°C) ..... 47

Figure 39 - The Effect of Extension Rate Changes on the Flow Stress of Alloy 800H at 1650°F (900°C) ..... 55

Figure 40 - The Effect of Extension Rate on the Yield Strength (left) and Ultimate Tensile Strength (right) at 900°C (1650°F)..... 55

Figure 41 - Estimated Hot Tensile Curves for Alloy 800H Based on the Consideration of the Effect of Slow Extension Rate (0.005/minute) on the Ultimate Tensile Strength..... 56

## FOREWORD

This document is the result of work resulting from Cooperative Agreement DE-NE0000288 between the U.S. Department of Energy (DOE) and ASME Standards Technology, LLC (ASME ST-LLC) for the Generation IV (Gen IV) Reactor Materials Project. The objective of the project is to provide technical information necessary to update and expand appropriate ASME materials, construction and design codes for application in future Gen IV nuclear reactor systems that operate at elevated temperatures. The scope of work is divided into specific areas that are tied to the Generation IV Reactors Integrated Materials Technology Program Plan. This report is the result of work performed under Task 13 titled “Extend Allowable Stress Values for Alloy 800H.”

ASME ST-LLC has introduced the results of the project into the ASME volunteer standards committees developing new code rules for Generation IV nuclear reactors. The project deliverables are expected to become vital references for the committees and serve as important technical bases for new rules. These new rules will be developed under ASME’s voluntary consensus process, which requires balance of interest, openness, consensus and due process. Through the course of the project, ASME ST-LLC has involved key stakeholders from industry and government to help ensure that the technical direction of the research supports the anticipated codes and standards needs. This directed approach and early stakeholder involvement is expected to result in consensus building that will ultimately expedite the standards development process as well as commercialization of the technology.

ASME has been involved in nuclear codes and standards since 1956. The Society created Section III of the Boiler and Pressure Vessel Code, which addresses nuclear reactor technology, in 1963. ASME Standards promote safety, reliability and component interchangeability in mechanical systems.

Established in 1880, the American Society of Mechanical Engineers (ASME) is a professional not-for-profit organization with more than 127,000 members promoting the art, science and practice of mechanical and multidisciplinary engineering and allied sciences. ASME develops codes and standards that enhance public safety, and provides lifelong learning and technical exchange opportunities benefiting the engineering and technology community. Visit [www.asme.org](http://www.asme.org) for more information.

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## ABSTRACT

The tensile, creep and stress-rupture databases for alloy 800H (UNS N08810) were assembled and analyzed with the intent of extending the allowable stresses in ASME Section III, Subsection NH for service to 500,000 h at 1400°F (760°C) and below and recommending new allowable stresses for limited service times to temperatures as high as 1650°F (900°C). Values for  $S_{Yl}$  and  $S_U$  were produced for the temperature range of 800 to 1650°F (425 to 900°C). These include a revision of existing values to 1500°F (800°C). Values for  $S_m$  were produced for the same temperature range. Values for the minimum stress-to-rupture,  $S_r$ , were produced for the temperature range of 800 to 1650°F (425 to 900°C), including a revision of existing values to 1400°F (750°C).

Development of values for  $S_t$  and  $S_{mt}$  required the construction of tensile curves to 1% strain, the estimation of the stresses to produce 1% creep strains to 500,000 h and the estimation of the minimum stress to initiate tertiary creep for times to 500,000 h. Because of the shortage of very long-time data for all categories, extensive use was made of time-temperature parametric models based on Larson-Miller. The observation of “non-classical” creep behavior in many of the creep curves for alloy 800H greatly reduced the confidence in the extrapolations needed to estimate stresses corresponding to the criteria on which the  $S_t$  and  $S_{mt}$  values were based. As a result, restrictions on the scope of the  $S_t$  values were recommended. These restrictions limited values to less than 500,000 h for temperatures of 1550°F (or 850°C) and above.

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## 1 INTRODUCTION

This work was undertaken in support of the ASME/DOE Generation IV Reactor Materials Program [1]. Most of the advanced nuclear reactor concepts being considered in the Generation IV effort will require that the structural materials operate at temperatures where time-dependent allowable stresses control. In the United States, the design and construction rules for the Class 1 nuclear components operating in the time-dependent temperature regime are provided in ASME Section III, Subsection NH (III-NH). Currently, only five materials are permitted in this construction code and one of the materials, namely alloy 800H (UNS N08810), is limited to service temperatures of 1400°F (760°C). To meet the design goals for some reactor concepts that require the use of alloy 800H, it has become desirable to extend the coverage for alloy 800H to higher temperatures and longer times [2]. Among the several tables and figures that need extension in III-NH are the following.

- (1) the yield strength,  $S_{Yt}$ , provided in Table I-14.5,
- (2) the ultimate strength,  $S_U$ , provided in Table NH-3225-1,
- (3) the minimum-stress-to-rupture,  $S_r$ , provided in Table I-14.6C,
- (4) the limiting time-independent strength,  $S_m$ , as represented by the lowest of the time-independent strength quantities defined in Section II, Part D,
- (5) the allowable limit of general primary membrane stress intensity,  $S_o$ , provided in Table I-14.3C,
- (6) the maximum allowable value of the general primary stress intensity,  $S_o$ , provided in Table I-14.2, and
- (7) the limiting temperature and time-dependent stress intensity,  $S_t$ , provided in Table I-14.4C.

Other data are needed that are identified in a recent review of the requirements of III-NH [3]. However, the activity reported here is restricted to the estimation of the stress intensity values listed above. The goal is to extend time to 500,000 h, if possible, and extend temperature to 1650°F (900°C), if possible.