

Specifications and Standards for Enhanced Casting Performance: Workforce Development Toolkit

Raymond Monroe, Rob Blair
Steel Founders' Society of America

Innovative Casting Technologies (ICT)

AMC Technology Review

August 17-18, 2022

Chicago, IL



Overview

Duration

| | | | | | |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

- **Needs and Benefits**
 - Improved engineering/procurement support
 - Improved industry workforce development
- **Progress**
 - Enhanced customer education
 - Easier casting alloy selection
 - Workforce development and production problem-solving resources
- **Transition**
 - Web based tools
 - Alloy database
 - Webinars/videos

Needs and Benefits

DoD

Engineering support with casting process videos and website materials, searchable specification data base, and webinars

Foundry / Casting Supplier / Industry

Searchable specification requirements and webinars

Web based basic skills and process information

Webinars on technical and commercial issues

Online resources to support casting designers and buyers

- Database contains spec composition and properties for 728 cast steel alloys
- Searchable by mechanical properties, chemistry, microstructure, alloy designation, UNS, ASTM/ISO standards etc.
- Searchable database in use by industry and members
- As of June 2022, 177 searches per month and growing

Standards and Specifications for Steel Castings

Description of how to search here

Properties/Chemistry By Standard

-Hardness-
 BHN HBW HRC

-Mechanical-
 Minimum elongation% Reduction in area
 Impact minimum Foot-pounds or Joules
 Tensile strength ksi or MPa
 Yield strength ksi or MPa
 100 hour rupture test MPa at temperature in °C
 Stress rupture test ksi or MPa

-Chemistry-
 Al% As% Ba% Bi% B% C% Co% Cr% Cu% Mn% Mo%
 N% Nb% Ni% P% S% Sb% Se% Si% Sn% Ta% Ti% V%
 W% Zr%

728 results found that match the specified search criteria

| Specification | Alloy Grade | Heat Treatment | UNS |
|------------------------------|-------------|----------------|-----|
| AAR M-201-16 | A | A or N | |
| AAR M-201-16 | A | Unannealed | |
| AAR M-201-16 | B | N or NT | |
| AAR M-201-16 | B+ | N or NT | |
| AAR M-201-16 | C | NT | |

| Specification | Alloy Grade | Heat Treatment ^A | UNS |
|------------------------------------|-------------|-----------------------------|--------|
| ASTM A351/A351M-16 | HK30 | as cast | J94203 |

[ABS 2/1.6-17](#) **Castings, Austenitic, Austenitic-Ferritic, For Pressure-Containing Parts**

[ABS 2/3.9-17](#) This specification covers austenitic and austenitic-ferritic (duplex) steel castings for valves, flanges, fittings, and other pressure-containing parts.

| C | Cr | Cr | Cu | Mn | Mo | Nb | Ni | Ni | N | P | Si | S | V |
|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| max | min | max | min | max | max | max | max | max | min | max | max | max | max |
| 0.35 | 0.25 | 27 | 23 | ... | 1.5 | 0.5 | ... | 22 | 19 | ... | 0.04 | 1.75 | 0.04 |

| Elong min% ^C | Tensile Strength ksi min | Tensile Strength MPa min | Yield Strength ksi min ^B | Yield Strength MPa min ^B |
|-------------------------|--------------------------|--------------------------|-------------------------------------|-------------------------------------|
| 10 | 65 | 450 | 30 | 240 |

A ST = to be solution treated. Refer to original specification for additional information on heat treatment requirements.

B Determine by the 0.2% offset method.

C When ICI test bars are used in tensile tests as provided for in this specification, the gage length to reduced section diameter ratio shall be 4:1.

- Webinars
 - 7 on cracking
 - 5 on corrosion
 - 11 on mold/metal challenges
 - 21 for customer education
 - 6 on data analysis techniques
 - 22 on others



Steel Castings: Properties and Performance

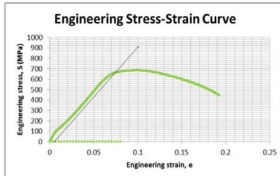
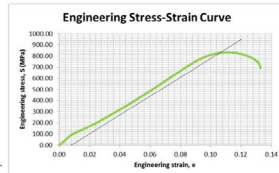


Table 2.1: Chemical composition of EN3 steel (OTAL 2015).

| %C | %Mn | %Si | %P | %S |
|-----------|-----------|-------------|-----------|-----------|
| 0.25 max. | 1.00 max. | 0.05 - 0.35 | 0.06 max. | 0.06 max. |

Table 4.1: Summary of tensile test results.

| Parameter | Un-notched (Eng-True) | Notched (Eng-True) |
|-------------|-----------------------|--------------------|
| $R_{m,EN3}$ | 582 MPa | 712 MPa |
| $R_{m,EN3}$ | 576 - 647 MPa | 721 - 817 MPa |
| A_5 | 19.3 - 17.6 % | 18 - 12 % |
| Z | 60.3 % | 62.8 % |



Elongation and Reduction of area are used to estimate ductility because they are easy and cheap, not because they give indications of performance.

Ductile failures are tearing.

Plastic deformation in failures at load is limited by geometry.

Production Welding Steel Castings



Completion Plans

Rob Blair, Raymond Monroe - SFSA

- Steel Casting Design Webinars – End of 2022
- Enable dramatically better steel casting designs for lower mass, assured design life, easier producibility, and lower final assembled total cost.
- Disseminate via the SFSA Website to casting buyers and industry - steel casting producers' foundry engineering teams, and OEM concept-to-production teams.
 - Story of the Casting Design Pathway
 - Freeway to Producer Response and Lower Prices
 - Castability Geometry
 - Castability Geometry Differs by Alloy Type
- Innovative application of GD&T

Completion Plans

Rob Blair, Raymond Monroe - SFSA

- Additional webinars
- Revise Steel Casting Handbook Supplement 6 – Welding
- Update Non-Destructive Testing (NDT) resources on SFSA website

Transition Plan

Rob Blair, Raymond Monroe - SFSA

- Promote value of educational courses and webinars to SFSA membership and DoD
 - At regular SFSA meetings
 - Technical & Operating Conference
 - Outreach via CAST-IT, etc.
- Support and involve industry partners
 - MetalTek, Badger Alloys, Bradken, Eagle Alloy, Harrison Steel Castings, Durametal, DW Clark



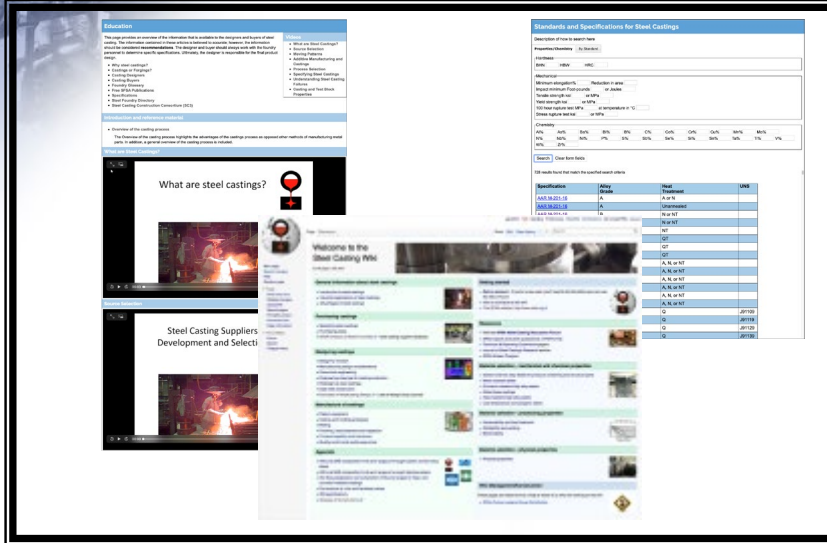
Leveraging

Rob Blair, Raymond Monroe - SFSA

- Uses AMC research work for wiki content
- Wiki includes:
 - SFSA Steel Castings Handbook
 - All research and conference papers, including DLA, DOE research results
 - Educational webinar videos available to steel foundries and military/government
- Workforce development for SFSA artisan program and industry's intern programs
- SFSA's Digital Innovative Design Program

Project Metrics

| Description | Baseline | Threshold | Goal | How Measured | Target Date | Progress | How Demonstrated |
|---|---|------------------------------|------------------|----------------|-----------------|--|-----------------------------|
| Six training webinars per year | 28 webinars as of Oct 2018 | Webinars available online | 6 webinars/yr | Uses per month | Sep 2022 | 72 webinars complete | Website analytical software |
| Two web courses per year | No courses exist | Training Video online | 2/yr | Uses per month | Sep 2022 | 8 courses online Developing additional course materials | Website analytical software |
| Two specification webinars per year | 2 webinars exist | Webinars available online | 2/yr | Uses per month | Sep 2022 | 7 webinars online | Website analytical software |
| Interactive specification Handbook Supplement | Steel Casting Specifications not searchable | Search tool available online | Online by 2/2020 | Uses per month | Sep 2022 | Searchable database publicly available 177 searches per month and growing Adding additional alloy grades | Website analytical software |



Problem

- The metalcasting industry needs to recruit, train, and retain a skilled workforce to support DLA / DoD. Specifications and workforce development are important to maintain a reliable supply base.

Objectives

- Develop and transition casting processes and design guidance, specifications, and standards to improve quality, performance, delivery, and cost.
- Development of a skilled future workforce.

Benefits to Warfighter

- Engineering support with casting tutorials, technical data, standards / specifications, requirements, and best practices
- Enhanced supplier capabilities / skilled workforce
- Optimized cast part performance

Description of Project:

This project will provide additional standards, specifications and workforce development tools to enhance the metalcasting supply chain by transitioning this data and the technology developed through ICT into metalcasting industry

Team:

Steel Founders' Society of America, ATI



Milestones / Deliverables

- Six SFSA workforce development webinars per year
- Interactive SFSA Specification Database