

# Cast in Steel – Halligan Bar

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## Abstract

The Cast in Steel competition strives to encourage students to learn about making steel products using the casting process and applying the latest technology available. This challenge is presented by the Steel Founders' Society of America (SFSA). Simulations of the liquid metal flow and finite element analysis on the Halligan bar were conducted to ensure the design was valid. The students cast the final Halligan bar design with a medium-carbon steel recipe at the Trine University Foundry. Then, the Halligan bar was cleaned, heat treated, polished, and coated. The final Halligan bar is 29.75 in. long with a 1 in. diameter handle and weighs 12.9 lbs. (5.85 kg.). With the final product, testing was conducted to ensure the strength and durability of the material would be able to withstand the final performance evaluation at the competition. The team traveled to the 2024 Cast in Steel competition in Milwaukee, WI to compete against other schools in a series of tests to prove the functionality and durability of their Halligan bar.

## Customer Needs and Requirements

Requirement	Unit	Value
Mass	Kilograms (kg)	≤ 6
Length	Inches (in)	≤ 40
Maintain Integrity Under Load	Safety Factor	≥ 1
Resist Surface Damage (Hardness)	Rockwell C	≥ 35
Casting Material	Pass/Fail	Steel
Industry Partner	Pass/Fail	Steel Foundry
College Student Status	Student(s)	≥ 1
Video Documenting Process	Minutes	≤ 5
Report Detailing Design and Process	Pages	≤ 30



## Material Selection

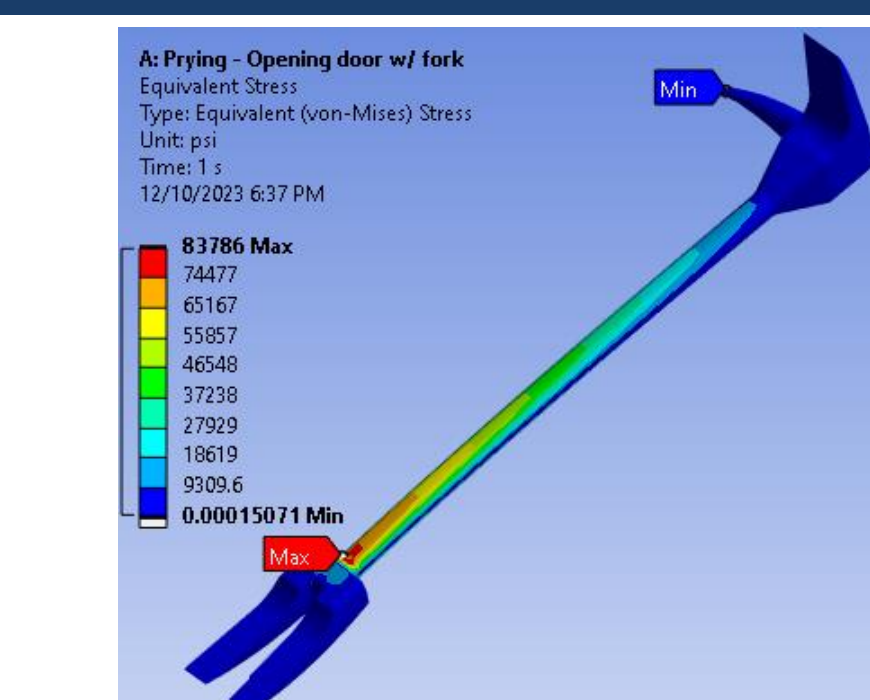
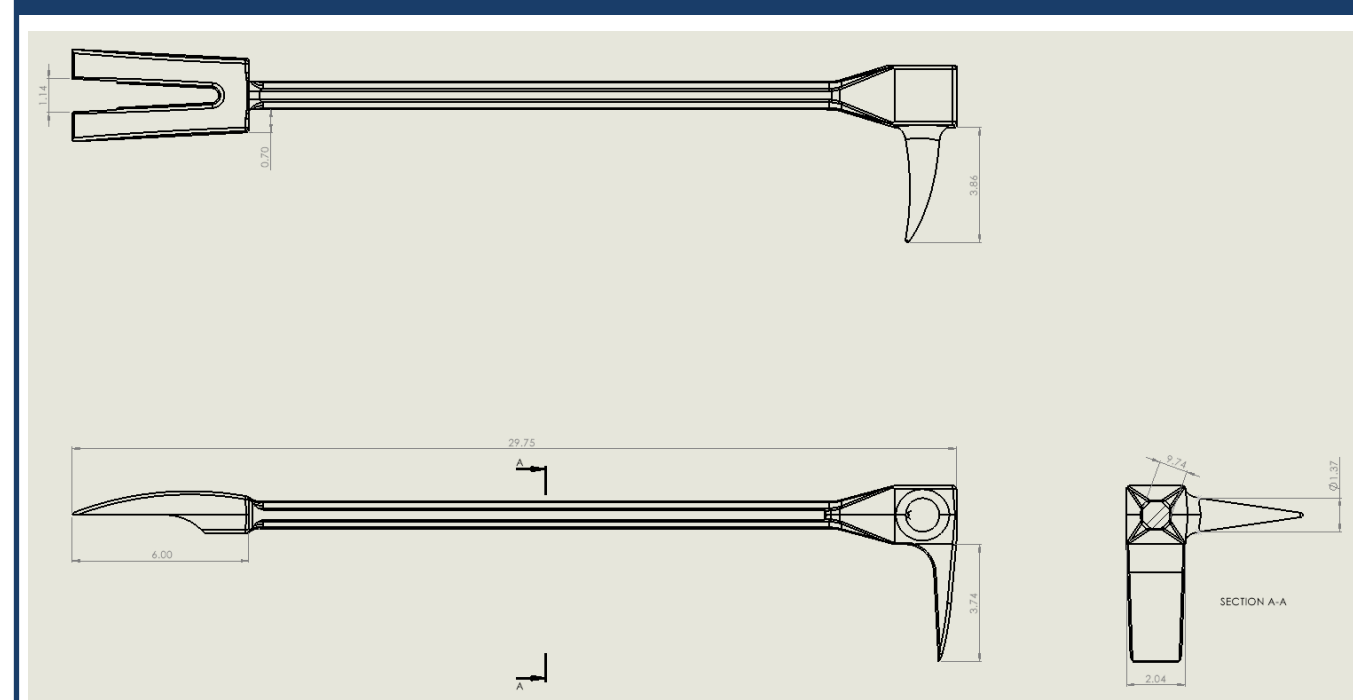


Because of the effects of the additives on the steel characteristics, this concentration of alloying elements were added.

For the competition, high impact, strength, and toughness properties are important. The alloy was developed with this in mind. Molybdenum, chrome, and carbon improve strength and wear resistance. Nickel preserves toughness while strength increases. The rest improve the purity of the metal and toughness.

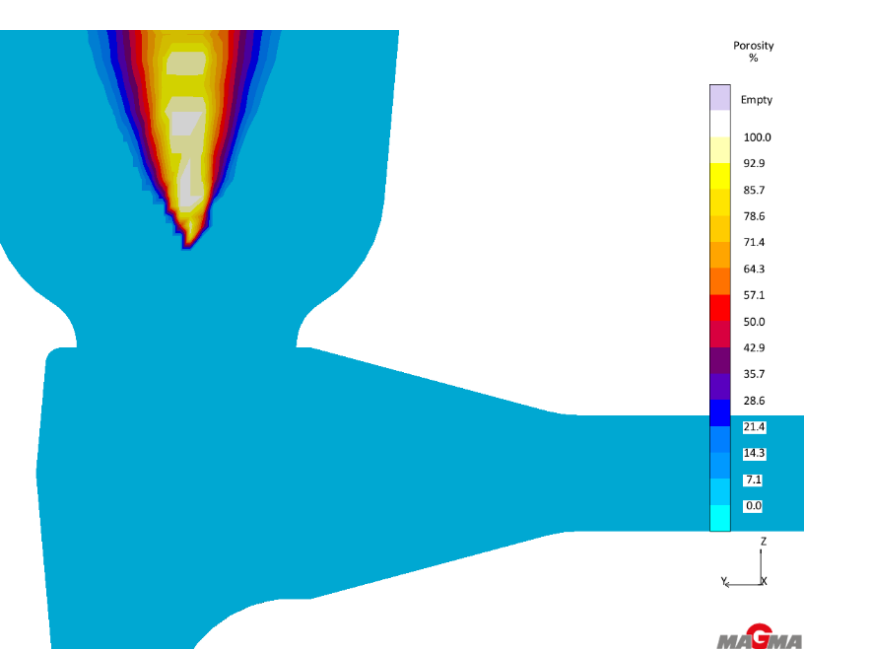
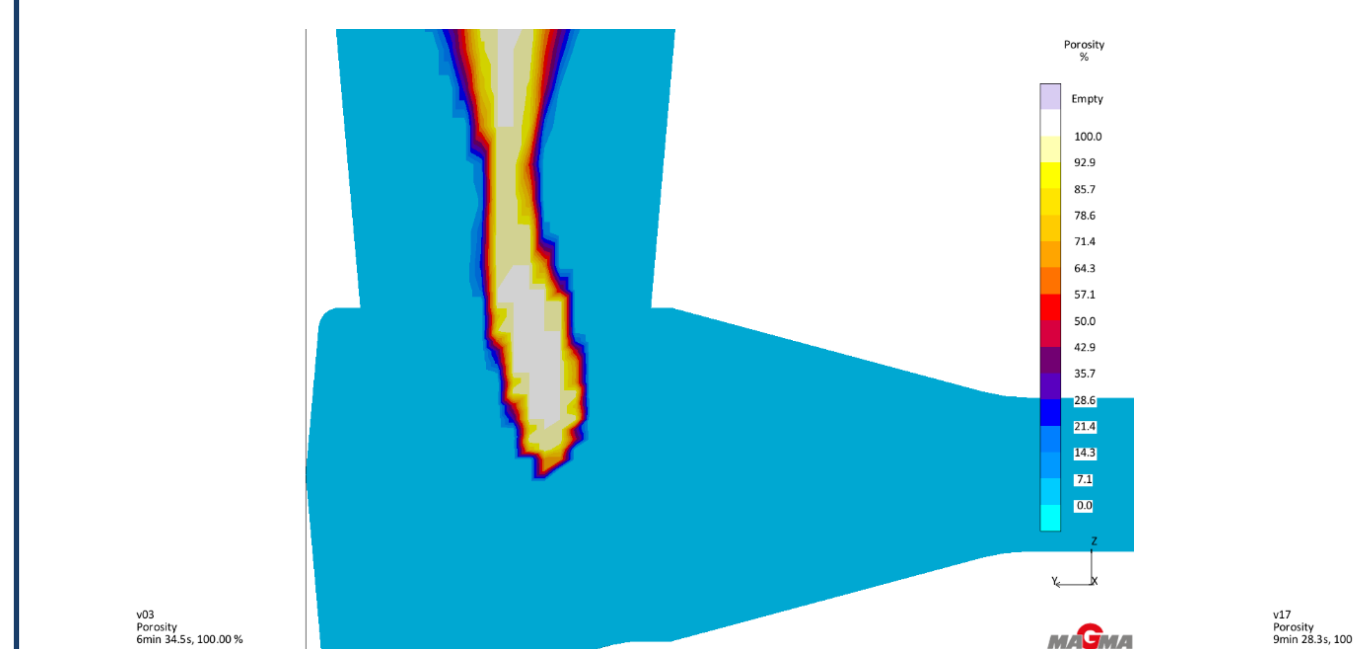
	Additives	Si	Al	Mn	Ni	C	Mo	Cr
Goal	Wt%	0.25	0.02	0.85	0.2	0.8	0.2	0.85
Actual	Wt%	0.15	0.06	0.379	0.185	0.6	0.188	0.92

## Design Solution



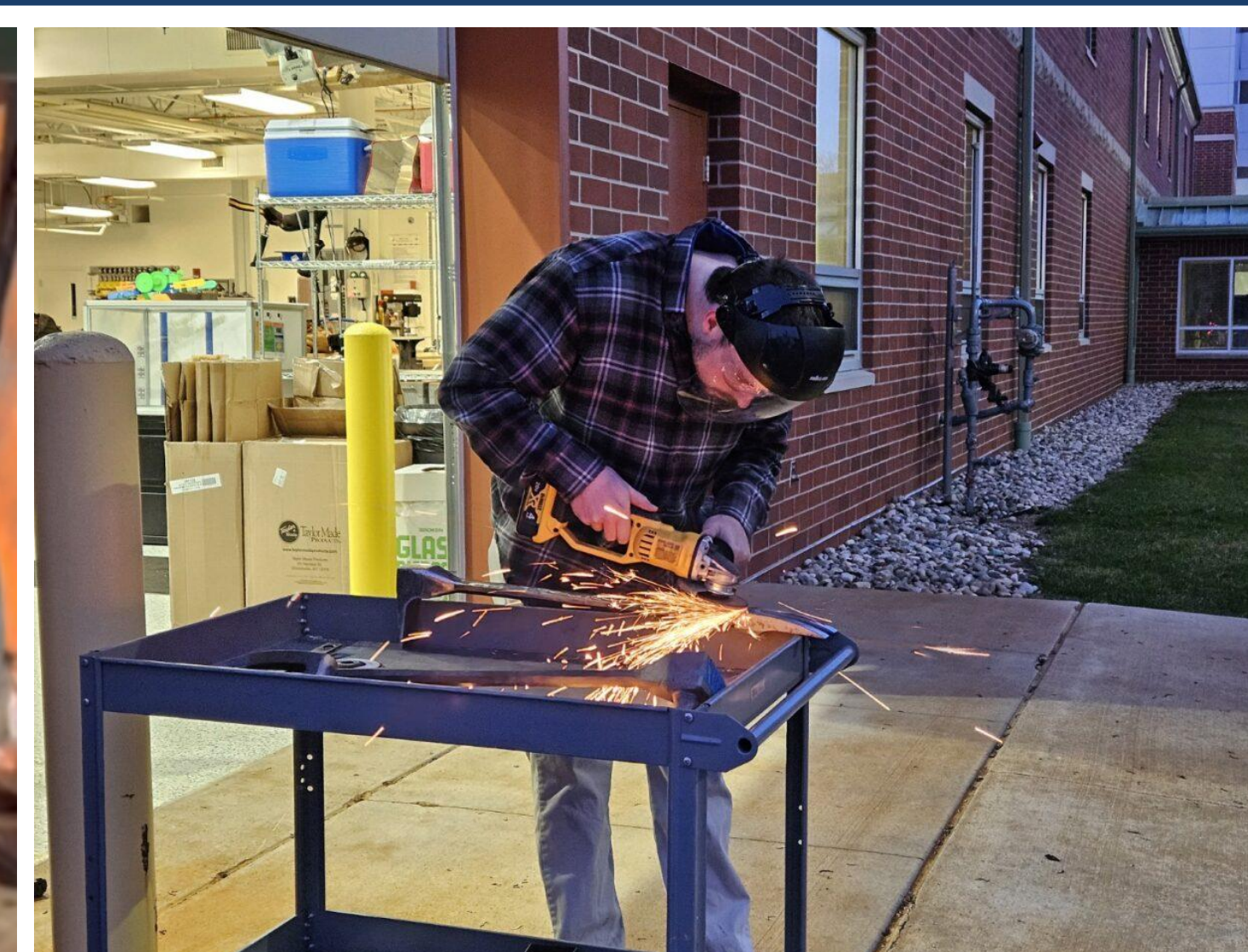
CAD drawing of final Halligan bar design

Finite Element Analysis (FEA)



MAGMA analysis conducted with MAGMASOFT.

## Manufacturing



Green sand molds were packed and poured at the Trine University Foundry. Two iterations of the Halligan bar were cast in steel.

The rough as-cast surface finish was ground smooth. Excess material and flash was also removed during this time. Four Halligan bars were ground to the desired weight and shape.

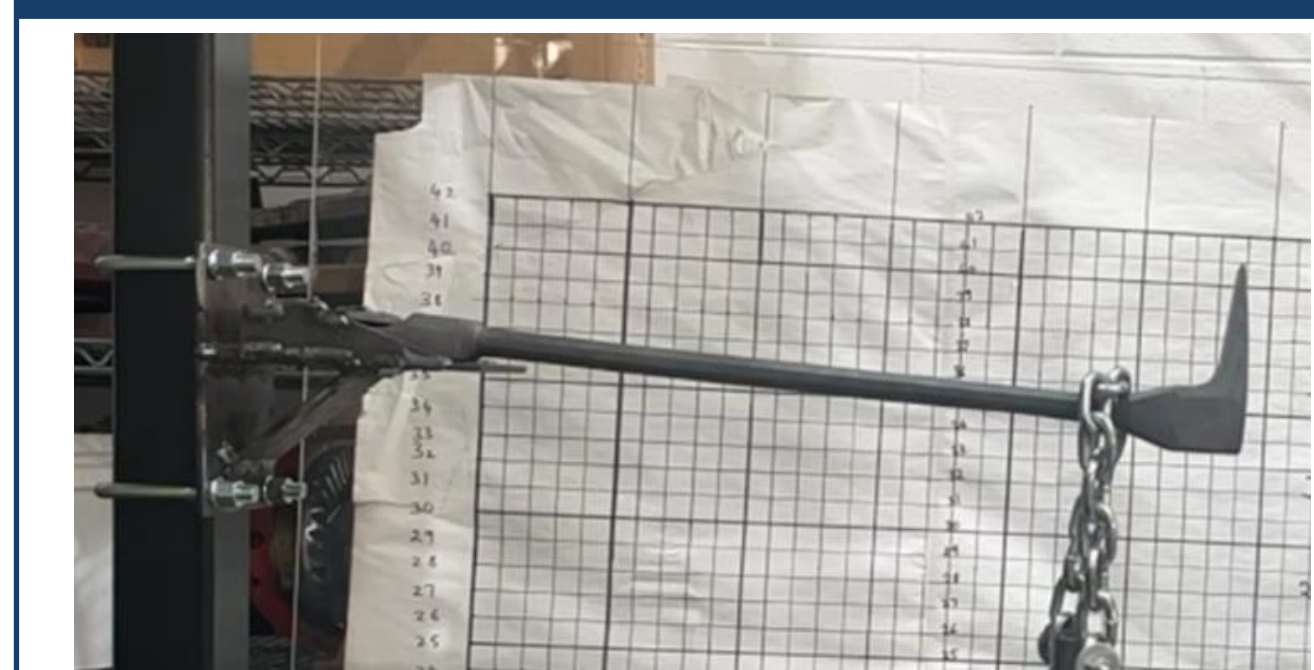


The same four Halligan bars were then sent to R&M Mfg. to be heat treated. The figure above shows a Halligan bar that has been heat treated.



The Halligan bars were then polished with 120 grit flap disks and coated with a layer of clear coat. A nonconductive FireWrap® Grip Kit was applied to the upper part of the Halligan Bar handle. The figure above shows the finalized Halligan bar.

## Testing and Validation



The prying (up) and twisting (down) tests were conducted to evaluate the Halligan bar's ability to maintain its integrity under extreme loading conditions. 300 lb. was hung off the end of the bar in each test. The grid board was used to see deflection.



The punching (right) and striking (left) tests were conducted to evaluate the Halligan bar's ability to resist surface damage from use. The pick was forced through 1/2 in. of drywall and 1/2 in. of OSB for the punching test. The forks and adze were hammered against a steel plate for the striking test.



Hardness testing was performed using a LECO LR310 Rockwell Hardness Tester (right). This machine applies a large load on the specimen with the necessary indenter to determine the hardness of the material.

Arc spectroscopy was conducted using a SPECTROMAXx Metal Analyzer (left). This machine uses an arc to determine the identity and number of atoms of an element in any given metal.



Tensile testing was performed at Metal Technologies in Auburn, IN. MTI received the as-cast tensile specimens, machined them to specification, and pulled them on their tensile testing machine (left).

## Acknowledgments



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