

REFERENCE DOCUMENT: Help Topics for CADS V3.0

- 1. Target Users for CADS Tool**
- 2. Main Menu with Inputs and Outputs**
- 3. Data Structure, Processes and Properties Definitions**

1. Target Users for CADs Tool:

Casting Alloy Data Search (CADs[®]) software is intended to be used as a search tool by OEM design engineers and foundry engineers, who are in the process of designing and developing new products and components, re-designing from existing non-metal cast products, and/or converting from other manufacturing processes for value engineering, and/or are looking for down selecting a suitable metal casting alloy, meeting the desired performance with respect to the its mechanical strength, fatigue, impact and flexural strength properties at room and elevated temperatures, including design allowables. The output from CADs can be exported digitally for structural analysis using FEA and casting process simulation. The tool offers three search options to users:

- I. **Select Alloy from Grade List:** This is designed for engineers just looking for engineering data of an alloy grade with pedigree information. This is generic drill down search for various alloy groups containing the list of currently available grades in each. Various alloy grades in each generic alloy groups such as ferrous and non-ferrous and sub-groups, for example, in case of ferrous iron, various grades, are listed. The initial and detail casting alloy search data with pedigree information such as chemical composition, designations, physical and mechanical properties can be printed, or saved into CSV file formats.
- II. **Strength Property Search:** This second option is for design engineers looking for suitable cast alloy (ferrous or non-ferrous) based on their minimum strength properties requirements, namely, ultimate tensile strength, yield strength and elongation (ductility). They can pick the desired minimum with the help of sliders for either ultimate strength and/or yield strength and/or elongation and CADs will list all the cast alloys that exceed the values picked with the sliders.
- III. **Global Alloy Search:** This first option is for engineers knowing the generic alloy grade name; but looking for the availability of the same alloy grade in various processes and/or section thickness and then finding the suitable grade and process that meets their requirements.

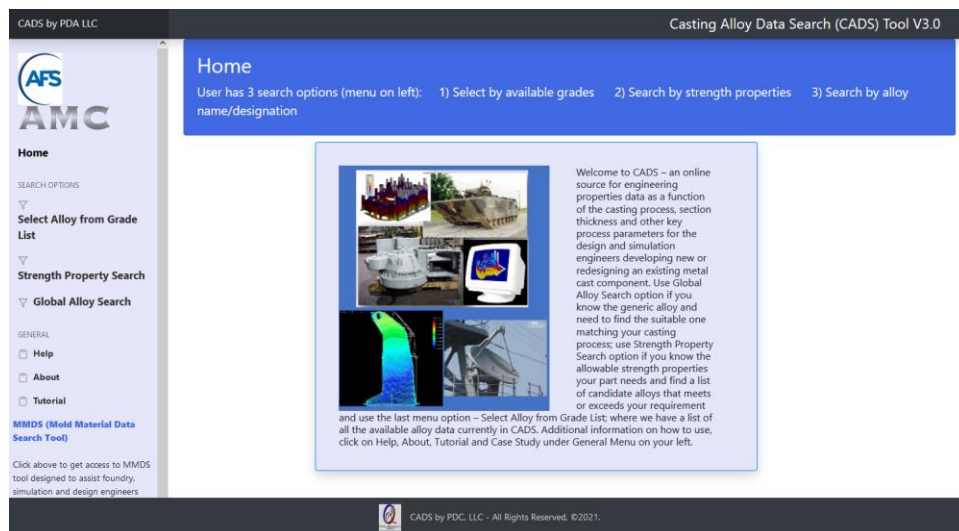


Figure 1: Home Page with Main Menu Options

2. Main Menu with Inputs and Outputs:

The three search options are on the left of the screen. By clicking on home button during the search, brings the user back to the main menu as shown in Figure 1 above.

On the left, under General, there are following useful links:

- i. **Help** – Links to this document.
- ii. **About** – Offers disclaimers about the software tool.
- iii. **Tutorial** – with examples on various search options available within CADS Tool.

Also, on left, by clicking on **MMDS** – Mold Material Data Search tool, another window will open.

The default unit system for CADS is in ksi, lbs, F and inch.

User can click on any one of the three options.

1. **Select Alloy from Grade List:** In this search option, after clicking on **Select Alloy from Grade List** on left, CADS will list all the currently available grades in various alloy types – Iron Alloy, Aluminum Alloys, Magnesium Alloys, Steel Alloys, Copper Alloys and Other Alloys consisting of Zinc alloys, Lead Alloys and Super Alloys. Figure 2 shows current list of the alloys in the database. User can use the slider under each category and scroll down and pick the alloy grade of interest. All the available data per various processes, molding methods and section thickness will be listed below, for example, by clicking on 356 under Aluminum Alloys, list of available data sets are listed in the search result as shown in Figure 3. User can print the results by clicking on **Print Results** button.

The screenshot shows the CADS Casting Alloy Data Search (CADS) Tool V3.0 interface. The sidebar on the left contains navigation links: Home, SEARCH OPTIONS, Select Alloy from Grade List, Strength Property Search, Global Alloy Search, GENERAL, Help, About, Tutorial, and MMDS (Mold Material Data Search Tool). The main content area is titled 'Search Available Grades' and displays six columns of alloy grades: Iron Alloys, Aluminum Alloys, Magnesium Alloys, Steel Alloys, Copper Alloys, and Other Alloys. Each column has a list of alloy grades and a 'Print Results' button at the bottom.

Figure 2: Select Alloy from Available Grades List Output

Search Available Grades

Aluminum Alloys: 356

Alloy Type	Alloy Name	Designation	Designation Number	Casting Process	Thickness	Select Alloy
Aluminum Alloys	356		A03560	Permanent Mold-Gravity/Tin Pour		Select Alloy
Aluminum Alloys	356		A03560			Select Alloy
Aluminum Alloys	356		A03560	Permanent Mold-Gravity/Tin Pour		Select Alloy
Aluminum Alloys	356		A03560	Pressure Diecasting	0.10 x 0.60	Select Alloy
Aluminum Alloys	356		A03560	Permanent Mold-Gravity/Tin Pour		Select Alloy
Aluminum Alloys	356		A03560	Squeeze/Semichill	1 x 0.83	Select Alloy
Aluminum Alloys	356		A03560	Vacuum Casting	1.29 x 1.60	Select Alloy
Aluminum Alloys	LowSi - 356 Sand	ASTM B26/B26M	12 Standard	Green Sand-Horizontally Parted Green Sand-Vertically Parted		Select Alloy
Aluminum Alloys	LowSi - 356PM	ASTM B108/B108M	12 Standard	Permanent Mold-Low Pressure	13mm	Select Alloy

Figure 3: Down selected 356 under Alluminum Alloys listing available various data sets for various processes and section thickness.

User then choses an alloy of interest by clicking on the Select Alloy button in green on right. Figure 4 below is the display of list of available properties in alphabetical order for Low Si 356 alloy selection.

LowSi - 356 Sand 12 Standard

Print Results | Export (csv) | Back to List

- ☐ Chemical Composition
- ☐ Mechanical Properties - Room Temperature Static
- ☐ Microstructure
- ☐ Monotonic Properties
- ☐ Processing Data
- ☐ Strain Life
- ☐ Reference with Citation

** Only those properties available in the current Database are shown above.

Figure 4: Selected Alloy Low Si 356 with the list of available data alphabetically including references with citation at bottom

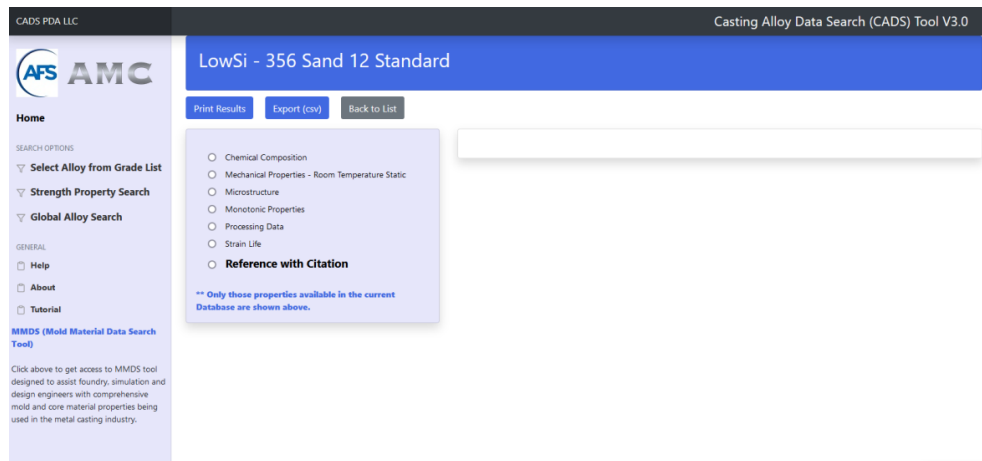


Figure 5: Low Si 356 selected alloy showing available properties

User has the option to choose one from the available data sets as shown in Figure 5 above. If user chooses, for example as shown in Figure 6 below, **Room Temp Static Mech Props** (room temperature static mechanical properties) properties by clicking into the box on left. All properties will be listed on the right side of the window with **Property Name** and the **Property Value**.

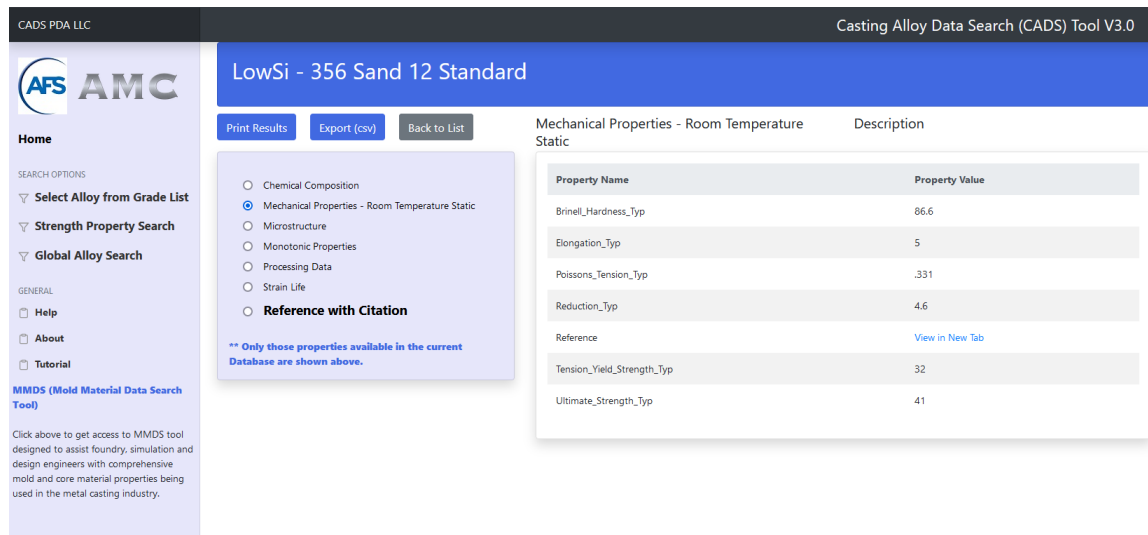


Figure 6: Low Si 356 Sand Cast Room Temperature Mechanical properties

All references with citation for this data set can be seen by clicking on Reference with Citation button and output will see like one below in Figure 7.

CADS PDA LLC Casting Alloy Data Search (CADS) Tool V3.0

AFS AMC

Home

SEARCH OPTIONS

- Select Alloy from Grade List
- Strength Property Search
- Global Alloy Search

GENERAL

- Help
- About
- Tutorial

MMDS (Mold Material Data Search Tool)

Click above to get access to MMDS tool designed to assist foundry, simulation and design engineers with comprehensive mold and core material properties being used in the metal casting industry.

LowSi - 356 Sand 12 Standard

Print Results Export (csv) Back to List

Reference with Citation

Description

Chemical Composition

Mechanical Properties - Room Temperature Static

Microstructure

Monotonic Properties

Processing Data

Strain Life

Reference with Citation

**** Only those properties available in the current Database are shown above.**

Title Design and Product Optimization for Cast Light Metals

Author USAMP-DOE-AFS

Citation USAMP-LMD 110 Project USAMP CRADA Agreement No. 94-MULT-AMP-0319, US Department of Energy (DOE)

Research Report Front Page [View in New Tab](#)

Detail Report For access to the detail report, click here to access AFS Virtual Library (only accessible to AFS Members and would require login and password credentials). Copy the title & author from above and paste into [AFS Virtual Library Search](#)

Figure 7: Reference with Citations for Low Si 356 -Sand alloy data

2. **Strength Property Search:** This search option is for design engineers looking for appropriate cast alloy grade that exceeds the minimum strength requirements for a cast product design. These are room temperature ultimate tensile strength, yield strength and elongation properties. User can choose either all 3 or any two or only one, using the blue colored slider bar as shown in Figure 8 below. In the example, user is looking for all the alloys that exceed ultimate tensile strength of 40 ksi; yield strength of 26 ksi and an elongation of 4%. Once the sliders are positioned to the desired values, click on **Search by Selected Properties** button in blue. A list of candidate alloys will be listed below as shown in Figure 8.

User picks LowSi-356-Sand cast alloy by clicking on the dark green colored button, Select Alloy and the output looks like as shown in Figures 9 through 7. Use can print the search results listing all the candidate alloys.

CADS PDC LLC Casting Alloy Data Search (CADS) Tool V3.0

AFS AMC

Home

SEARCH OPTIONS

- Global Alloy Search
- Strength Property Search
- Select Alloy from Grade List

GENERAL

- Help
- About
- Tutorial

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Search Property Strength

Ultimate Tensile Strength (ksi) 0 350 Value: 40

Yield Strength (ksi) 0 254 Value: 26

Elongation % 0 50 Value: 3

Search by Selected Properties Print Results

Alloy Type	Alloy Name	Designation	Designation Number	Casting Process	Thickness	
Iron	125-80-10	ASTM A 897/A 897M	125-80-10 [850-550-10]	Air-Set/No Bake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand	1 in	Select Alloy
Iron	150-100-7	ASTM A 897/A 897M	150-100-7 [1050-700-7]	Air-Set/No Bake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand	1 in	Select Alloy
Iron	175-125-04	ASTM A 897/A 897M	175-125-04 [1200-850-04]	Air-Set/No Bake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand	1 in	Select Alloy
Iron	200-155-01	ASTM A 897/A 897M	200-155-01 [1400-1100-01]	Air-Set/No Bake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand		Select Alloy
Iron	80-55-06	ASTM A 536 [SAE J434]	80-55-06 [D5506]	Air-Set/No Bake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand		Select Alloy

Iron	Grd 400	ASTM A 842 [SAE J1887]	Grd 400 [Grd 400]	Air-Set/NoBake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand	25mm	Select Alloy
Aluminum Alloys	356		A03560	Permanent Mold-Gravity/Tilt Pour		Select Alloy
Aluminum Alloys	356		A03560	Squeeze/Semisolid	1 x 0.83	Select Alloy
Aluminum Alloys	356		A03560	Vacuum Casting	1.29 x 1.60	Select Alloy
Iron	High Silicon Molybdenum	SAE J2582		Air-Set/NoBake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand	.625	Select Alloy
Iron	110-70-11	ASTM A897/A897M-06	110-70-11	Air-Set/NoBake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand	48 mm by 43 mm by 165 mm section of rectangular casting	Select Alloy
Iron	200-155-1	ASTM A897/A897M	200-155-1	Air-Set/NoBake Gas-Hardened/Coldbox Green Sand-Horizontally Parted Green Sand-Vertically Parted Shell Mold V-Process Sand	1 in	Select Alloy
Aluminum Alloys	357	E357-T6		Air-Set/NoBake	1	Select Alloy
Aluminum Alloys	357	E357-T6		Air-Set/NoBake	2	Select Alloy
Aluminum Alloys	LowSi - 356 Sand	ASTM B26/B26M	12 Standard	Green Sand-Horizontally Parted Green Sand-Vertically Parted		Select Alloy
Aluminum Alloys	LowSi - 356PM	ASTM B108/B108M	12 Standard	Permanent Mold-Low Pressure	13mm	Select Alloy
Aluminum Alloys	E357 50 mm	SAE AMS 4288	Standard		2 inch	Select Alloy

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Figure 8: Search by minimum Strength properties of ultimate strength of 40 ksi, yield strength of 26 ksi and elongation of 3%.

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Casting Alloy Data Search (CADS) Tool V3.0

AFS AMC

Home

SEARCH OPTIONS

Select Alloy from Grade List

Strength Property Search

Global Alloy Search

GENERAL

Help

About

Tutorial

MMDS (Mold Material Data Search Tool)

Click above to get access to MMDS tool designed to assist foundry, simulation and design engineers with comprehensive mold and core material properties being used in the metal casting industry.

LowSi - 356 Sand 12 Standard

Print Results Export (csv) Back to List

☐ Chemical Composition
 ☐ Mechanical Properties - Room Temperature Static
 ☐ Microstructure
 ☐ Monotonic Properties
 ☐ Processing Data
 ☐ Strain Life
 ☐ Reference with Citation

** Only those properties available in the current Database are shown above.

Figure 9: Low Si 356 selected alloy showing available properties

User has the option to choose one from the available data sets as shown in Figure 9 above. If user chooses, for example as shown in Figure 10 below, **Room Temp Static Mech Props** (room temperature static mechanical properties) properties by clicking into the box on left. All properties will be listed on the right side of the window with **Property Name** and the **Property Value**.

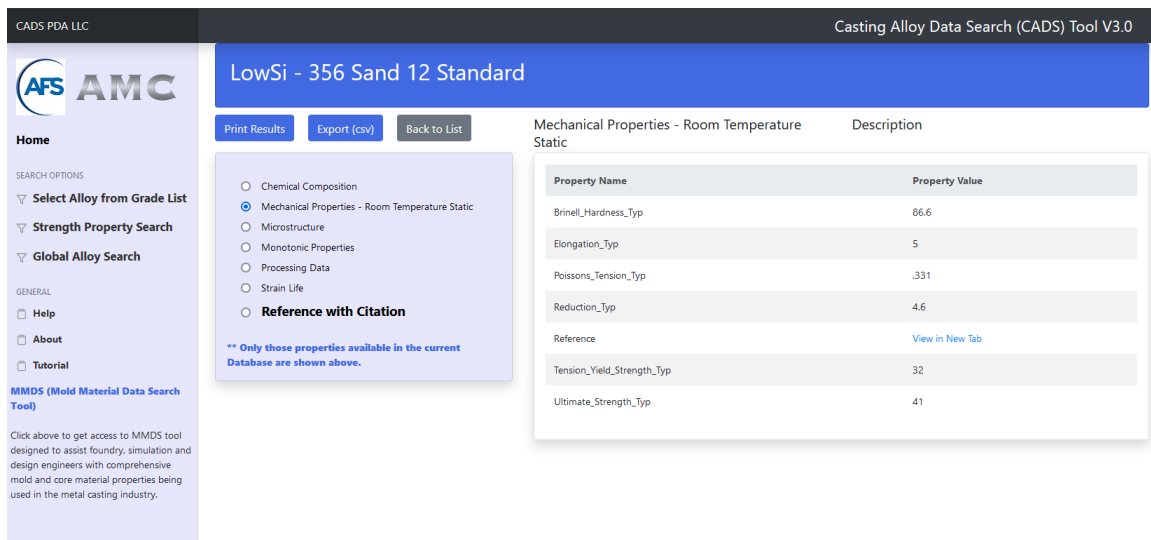


Figure 10: Low Si 356 Sand Cast Room Temperature Mechanical properties

All references with citation for this data set can be seen by clicking on Reference with Citation button and output will see like one below in Figure 11.

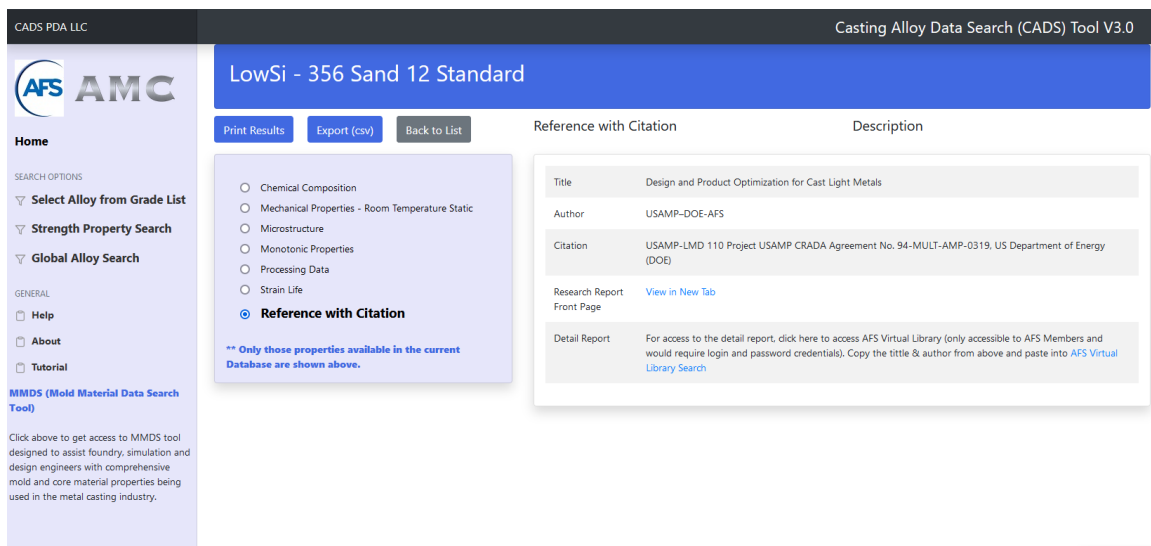


Figure 11: Reference with Citations for Low Si 356 -Sand alloy data

- 3 **Global Alloy Search:** By clicking on global alloy search button, the following menu shows up as shown in Figure 12. As shown as an example, a user is looking for 356 alloy grades for the available data for various processes with pedigree information, such as section thickness. A list of available data for 356 alloy grades under various processes and available section thickness shows up below. The search result can be printed by clicking on **Print Results** button.

The screenshot shows the 'Global Alloy Search' interface. At the top, there's a search bar with '356' entered and a 'Find' button. Below the search bar is a 'Print Results' button. The main content is a table with columns: Alloy Type, Alloy Name, Designation, Designation Number, Casting Process, and Thickness. The table lists several entries for Aluminum Alloys 356, including different casting processes like Permanent Mold-Gravity/Tilt Pour, Pressure Diecasting, and Vacuum Casting, along with their respective thicknesses. Each row has a 'Select Alloy' button on the right.

Alloy Type	Alloy Name	Designation	Designation Number	Casting Process	Thickness
Aluminum Alloys	356		A03560	Permanent Mold-Gravity/Tilt Pour	
Aluminum Alloys	356		A03560		
Aluminum Alloys	356		A03560	Permanent Mold-Gravity/Tilt Pour	
Aluminum Alloys	356		A03560	Pressure Diecasting	0.10 x 0.60
Aluminum Alloys	356		A03560	Permanent Mold-Gravity/Tilt Pour	
Aluminum Alloys	356		A03560	Squeeze/Semisolid	1 x 0.83
Aluminum Alloys	356		A03560	Vacuum Casting	1.29 x 1.60
Aluminum Alloys	LowSi - 356 Sand	ASTM B26/B26M	12 Standard	Green Sand-Horizontally Parted Green Sand-Vertically Parted	

Figure 12: Global Alloy Search Menu for 356

Then, click on **Select Alloy** (dark green colored) button for the detail data. For example, here, 8th entry under **LowSi-356 Sand** is chosen by the user and Figure 13 displays the output as shown below.

The output for the selected alloy property data can be printed or exported into Excel (CSV) formats by clicking **Print Results** and **Export (csv)** buttons respectively as shown in Fig 13. If user wants to go back and look at the list of alloys, can do so by clicking **Back to List** button.

The screenshot shows the 'LowSi - 356 Sand 12 Standard' property outputs. At the top, there's a blue header with the title. Below the header are buttons for 'Print Results', 'Export (csv)', and 'Back to List'. The main content is divided into two sections: 'Microstructure' and 'Description'. The 'Microstructure' section has a list of properties with radio buttons: Chemical Composition, Mechanical Properties - Room Temperature Static, Microstructure (selected), Monotonic Properties, Processing Data, Strain Life, and Reference with Citation. The 'Description' section has a table with columns 'Property Name' and 'Property Value'. The table lists 'Grain_Size' (Medium), 'Reference' (View in New Tab), and 'Typical_Microstructure_Photo' (View in New Tab).

Property Name	Property Value
Grain_Size	Medium
Reference	View in New Tab
Typical_Microstructure_Photo	View in New Tab

Figure 13: LowSi-356-Sand Property Outputs - Microstructure

Other property option, for example, **Microstructure**, if any micrographs are available, will be shown highlighted in blue as shown in Figure 6 above and by clicking **View in New Tab**, another window will open showing the JPEG image of the microstructure as shown below in Figure 14. Similarly, any **Reference** documents if any linked to the data, is hyperlinked and highlighted in blue and will open another window showing the PDF document page.

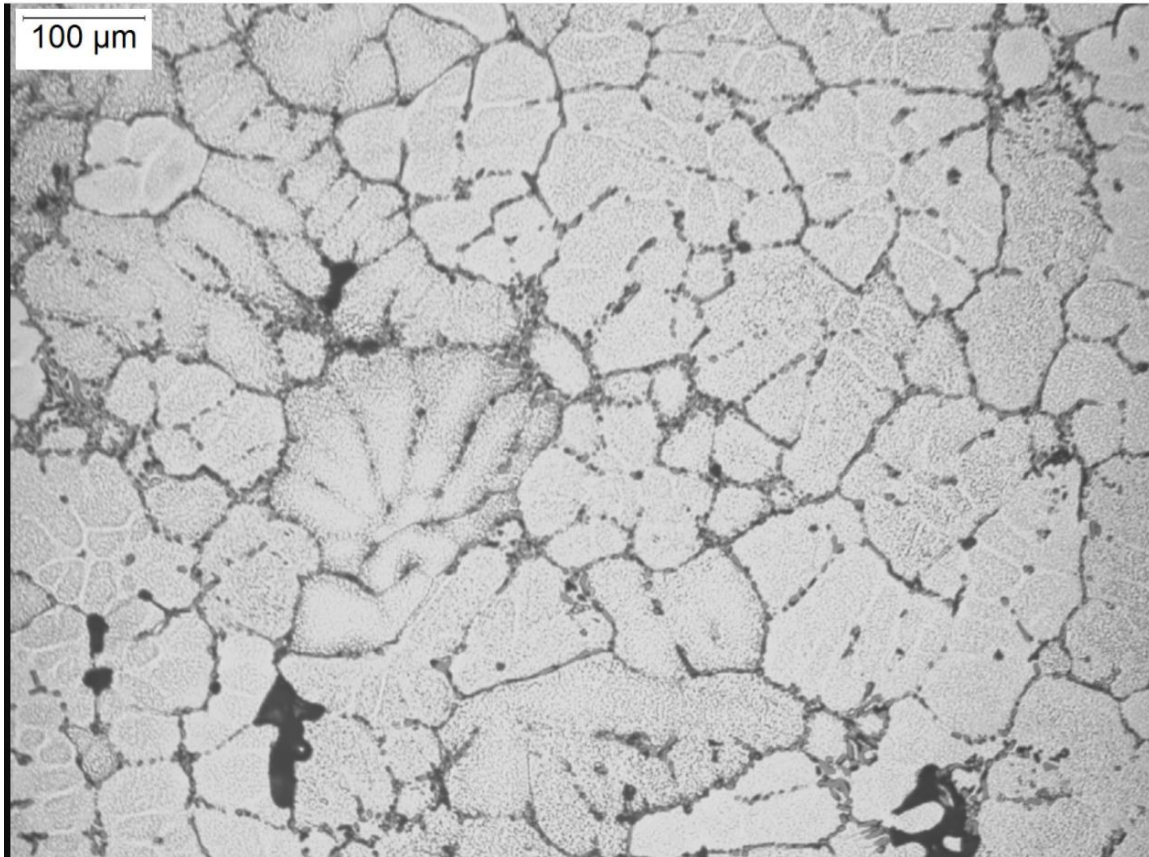


Figure 14: LowSi-356-Sand Typical Microstructure Image

3.Data Structure, Processes and Properties Definitions:

1. **Alloy Types:** Current CADS database is structured per the following broad alloys:

1. Ferrous
 - a. Iron
 - i. Gray Iron
 - ii. Ductile Iron
 - iii. Compacted Graphite Iron
 - iv. Austempered Ductile Iron
 - v. Malleable Iron
 - vi. Abrasion Resistant Iron
 - vii. Corrosion Resistant Iron
 - viii. Heat Resistant Iron
 - b. Steel
 - i. Carbon Steels
 - ii. Low Alloy Steels
 - iii. Corrosion-Resistant Steels
 - iv. Heat-Resistant Steels
 - v. Manganese Steels

2. Nonferrous

- a. Aluminum Alloys
 - i. Aluminum-Copper (200 series)
 - ii. Aluminum-Silicon (300 Series)
 - iii. Aluminum-Silicon (400 Series)
 - iv. Aluminum-Magnesium (500 Series)
- b. Copper Alloys
 - i. Red/Yellow Brass/Tin-Bronze
 - ii. High Copper Alloys
- c. Zinc-Base
- d. Lead Alloys
- e. Magnesium Alloys

3. Superalloys

- a. Nickel-Base
- b. Titanium
- c. Cobalt-Base
- d. Other Superalloys

2. **Casting / Molding Processes:** Following processes are considered for capturing the pedigree information

1. Sand Casting (Green Sand, Horizontal and Green Sand, Vertical, Air Set, No-bake, CO₂, Cold Box,)
2. Shell Molding
3. Lost-Foam (EPC, Full-Mold)
4. Vacuum Casting
5. Investment Casting
6. Ceramic Molding
7. Plaster Casting
8. Permanent Mold (Gravity/Tilt Pour, Low Pressure)
9. Die Casting (High pressure)
10. Squeeze Casting
11. Centrifugal Casting

3. **Chemical Composition** – Database has captured maximum, minimum and typical compositions abbreviated as **A**, **B** and **C** in the output, all elements are listed in the first column under **Property Name**. Please see Figure 15 below.

CADS PDA LLC

Casting Alloy Data Search (CAD5) Tool

LowSi - 356 Sand 12 Standard

Print Results Export (csv) Back to List

Chemical Composition Value Wt% (A=Max B=Min C=Typical)

Property Name	Property Value
Ca	C) .005
Cr	C) .005
Cu	A) .25 C) .005
Fe	A) .6 C) .11
Mg	A) .45 C) .33
Mn	A) .35 C) .005
Ni	C) .005
P	C) 0.005
Reference	View in New Tab
Si	A) 4 C) 3.9
Sn	C) .005
Sr	C) .03
Ti	A) .25 C) .01
Zn	A) .35 C) .01

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Figure 15: Chemical composition typical out put (example LowSi-356-Sand)

4. **Section Thickness** – The critical cross-section thickness, which will correspond to the test bar thickness, from which the mechanical properties have been derived. The section thickness in most alloys impact the cooling rates and final microstructure and properties.
5. **Service Temperature** – In the data base, there are Room Temperature or Elevated Temperature options available. The database has minimum, maximum and typical properties as available.
 1. **Room Temperature Properties:**
 - a. Brinell Hardness (500 kg load on 10 mm ball)
 - b. Compressive Yield Strength (set at 0.2% off-set) in ksi
 - c. Elongation in % in 2-inch dia.
 - d. Hardness in HRC
 - e. Poisson's Ratio
 - f. Reduction in area, %
 - g. Shearing Strength, ksi
 - h. Tension Yield Strength (set 0.2% or 0.5%), ksi
 - i. Ultimate Tensile Strength, ksi
 - j. Young's Modulus, ksi
 2. **Elevated Temperature Properties:** tensile or compressive strength in ksi
6. **Fatigue Strength:** Strain-life fatigue-based values are provided for iron, aluminum and steel family of various grades. Some of the data are in a graphical form as PDF or JPEG, or tables and others are listed with values. The following is the list of all the fatigue related properties captured into CADs; only select alloys have some of these properties:
 1. Cyclic Strain Hardening Exponent (n')
 2. Cyclic Strength Coefficient (K') in ksi
 3. Cyclic Yield Strength in ksi
 4. Elastic Modulus in ksi
 5. Endurance Limit / Fatigue Limit in ksi
 6. Fatigue Ductility Exponent ϕ
 7. Fatigue Strength Coefficient ($s'f$) in ksi
 8. Fatigue Strength Exponent (b)
 9. Strain Curve
 10. Strength Coefficient (K) in ksi
 11. Strain Hardening Exponent (n)
 12. True Fracture Ductility
 13. True Fracture Strength in psi
 14. True Yield Strength in psi
 15. Cyclic Strength Coefficient (K') in ksi
7. **Impact Property:** For desired room or operating temperature, Charpy in inch-lbs min and maximum and typical values are contained in the database.
8. **Flexural Strength:** From the desired room temperature compression or tension strength in ksi min and maximum, values
9. **Design Allowable:** There are two sources for design allowable properties: MMPDS (Metallic Material Properties Development & Standardization; an organization maintaining the material data derived using statistical methods of A, B and S allowable, mainly used by the aircraft and aerospace community as well as Military. The second source is derived by AFS using MMPDS methods using member foundries provided production historical test bar properties

data with significant number of heats or lots. Below Figure 16 shows an example for Aluminum Alloy E357 data, listing Design Allowables. By clicking Design Allowables button, the display of the available properties is displayed as shown in Figure 17 below.

CADS PDA LLC Casting Alloy Data Search (CADSDA) Tool V3.0

E357-MMPDS-T A03570

Print Results Export (csv) Back to List

SEARCH OPTIONS

- Select Alloy from Grade List
- Strength Property Search
- Global Alloy Search

GENERAL

- Help
- About
- Tutorial

MMDS (Mold Material Data Search Tool)

Click above to get access to MMDS tool designed to assist foundry, simulation and design engineers with comprehensive mold and core material properties being used in the metal casting industry.

Available Properties:

- Chemical Composition
- Design Allowables
- Flexural Strength
- Impact Properties
- Mechanical Properties - Room Temperature Static
- Physical Properties
- Processing Data
- Reference with Citation

**** Only those properties available in the current Database are shown above.**

Figure 16 Listing of all available data including Design Allowable for Aluminum E357

CADS PDA LLC Casting Alloy Data Search (CADSDA) Tool V3.0

E357-MMPDS-T A03570

Print Results Export (csv) Back to List

Design Allowables

Description

Property Name	Property Value
Ultimate Tensile Strength (ksi)	A-basis = 46; B-basis = 48; S-basis = 45
Yield Strength (ksi)	A-basis = 40; B-basis = 43; S-basis = 36
Elongation (%)	A-basis = 3; B-basis = 4; S-basis = 2
Table or Figure	View in New Tab
Number of Heats	125
Definition of Design Allowable	View in New Tab
Source of Data	MM/PDS
Citation	View in New Tab

Figure 17 Display of Design Allowable for Aluminum E357

By clicking on Table or Figure, additional design allowable properties as contained in MMPDS handbook get displayed in another window of your browser. Figure 18 below shows an example of such table.

MMPDS-11
1 July 2016

**Table 3.9.7.0(c). Design Mechanical and Physical Properties of E357.0
Aluminum Alloy Casting**

Aluminum Alloy Casting			AMS 4288		
Specification	Investment Casting ^a		Sand Casting ^b		
Form	T6				
Temper	T6				
Thickness, in.	0.500-2.500		...
Location Within Casting	Designated area	Non-Designated area	Designated area		Non-Designated area
	S	S	A	B	S
Mechanical Properties:					
F_{tu} , ksi	50	45	46	48	45
F_{ty} , ksi	40	36	40 ^c	43	36
F_{cy} , ksi	41	37	42	44	36
F_{ux} , ksi	33	30	32	34	31
F_{brs}^d , ksi:					
(e/D = 1.5)	75	67
(e/D = 2.0)	98	88	78	86	...
F_{brs}^d , ksi:					
(e/D = 1.5)	59	53	61	65	52
(e/D = 2.0)	69	62	75	78	64
e , percent (S-Basis)	3	2	3	...	2
E , 10^3 ksi	10.4		10.6		
E_c , 10^3 ksi	10.5		10.8		
G , 10^3 ksi	3.9		3.9		
μ	0.33		0.33		
Physical Properties:					
α , lb/in. ³	0.097				
C , Btu/(lb)(°F)	0.23 (at 212°F)				
K , Btu/(hr)(ft ²)(°F)/ft]	88 (at 77°F)				
α , 10^{-6} in./in./°F	12.0 (68°F to 212°F)				

Issued: Apr-2005, MMPDS-02, Item 02-02. Last revised: July 2016, Item 13-40.

a. Properties were determined from investment cast plates.

b. Properties were determined from step geometry.

c. A-Basis is specification minimum. The rounded T_{62} = 42 ksi.

d. Bearing values are "dry pin" values per Section 1.4.7.1.

Figure 18 Design Allowable properties as contained in MMPDS Handbook