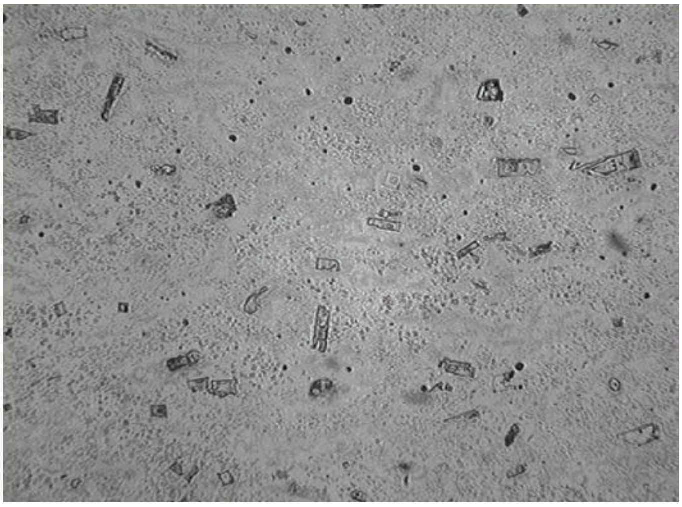
WALLCOLMONOY LTD. (UK)
TECHNICAL DATA SHEET

Colmonoy® 88 Alloys:

(88F, 88B, 88C, 88SA, 88M, 88P1, 88P2, 88H, 88R-H)

Nickel-Based Hard-Surfacing Alloys with the Element Tungsten for Greater Wear-Resistance, Versatility, and Value



Photomicrograph of **Colmonoy® 88** (original at 200x)

Description:

Colmonoy® 88 alloys include 88F, 88B, 88C, 88SA, 88M, 88P1, 88P2, 88H, 88R-H. Colmonoy® 88 alloys are unique, containing fine, multiple hard phases which are uniformly distributed throughout a Ni-Cr-B matrix.

These hard phases are comprised of complex bi- and tri- metallic borides and carbides, which are precipitated during manufacturing, and are an inherent part of the microstructure and not added externally as in conventional composite powders. The hard phases remain uniformly distributed during shipping, spraying, and fusing to ensure consistent performance throughout the coating and will not erode prematurely. Their fine size (5-10 microns) contributes to better finishing characteristics. The hard phases, along with the high-hardness Ni-Cr-B matrix, resist extreme abrasion and corrosion.

Colmonoy® 88 alloys can be spray deposited and fused to achieve a hardness range of **Rockwell C 59-64***. Colmonoy® 88R-H is a modified version of Colmonoy® 88H with improved ductility and reduced hardness. Colmonoy® 88R-H has a typical hardness range of **Rockwell C 55-60.**

Colmonoy® 88 alloys has proved successful in increasing the service life of glass mould plungers, where the alloy withstands wear from hot (982°C (1800°F)), extremely abrasive, molten silica. Colmonoy® 88 alloys are also recommended for hard surfacing of petroleum industry components such as gate valves, pump sleeves, pump shafts, bushings, wear rings and compressor rods.

Nominal Composition - % by Weight:

	B	C	Cr	Fe	Si	W	Ni
88F / 88B / 88C / 88SA / 88M / 88P1 / 88P2 / 88H	3.0	0.8	17.0	3.5	4.0	17.0	Bal
88R-H	2.6	0.6	13.5	3.75	3.75	15.0	Bal

*Dependent on application type, equipment used & parameter settings.

Forms Available:

Colmonoy® 88 alloys are supplied as atomised powder for application with Wall Colmonoy's Spraywelder™ System, Fusewelder™ Torch and other commercially available thermal spray, HVOF and puddle torch systems. Wire and rod also available.

<table>
<tr><th>Alloy</th><th>Mesh Size</th><th>Application</th></tr>
<tr><td>Colmonoy® 88F</td><td>106 µm - 20 µm</td><td rowspan="5">Spray & Fuse</td></tr>
<tr><td>Colmonoy® 88B</td><td>75 µm - 20 µm</td></tr>
<tr><td>Colmonoy® 88C</td><td>90 µm - 38 µm</td></tr>
<tr><td>Colmonoy® 88SA</td><td>106 µm - 38 µm</td></tr>
<tr><td>Colmonoy® 88M</td><td>125 µm - 45 µm</td></tr>
<tr><td>Colmonoy® 88P1</td><td>180 µm - 75 µm</td><td rowspan="2">PTA / Laser</td></tr>
<tr><td>Colmonoy® 88P2</td><td>150 µm - 63 µm</td></tr>
<tr><td>Colmonoy® 88H / 88R-H</td><td>63 µm - 20 µm</td><td>HVOF</td></tr>
</table>

Colmonoy® 88F, 88B, 88C, 88SA, 88M:

Colmonoy® 88F, 88B, 88C, 88SA and 88M are designed for Spray & Fuse applications, using combustion thermal spray systems such as the J-3 Spraywelder™ and Fusewelder™ Torch.

Colmonoy® 88M is designed for use with thermal spray systems that are more oxidising, thereby requiring a coarser material to achieve a quality coating.

Fused coatings form a metallurgical bond with the substrate providing inter-particle cohesive strength and substrate-to-coating adhesive strength with very low porosity. The coatings show good resistance to wear (Table 3) and impact and their hot hardness is excellent (Table 4).

Colmonoy® 88H:

Colmonoy® 88H is designed for use in HVOF Systems and do not require fusing. (Tables 5, 6 & 7)

Colmonoy® 88H is used for centrifugal pump parts, heat exchanger tubes and other non-point loading applications. The coating is well suited for applications requiring abrasion and corrosion resistance, particularly in the as-sprayed condition when fusing is not possible. The coatings are also used to protect against particle erosion up to 815°C (1500°F).

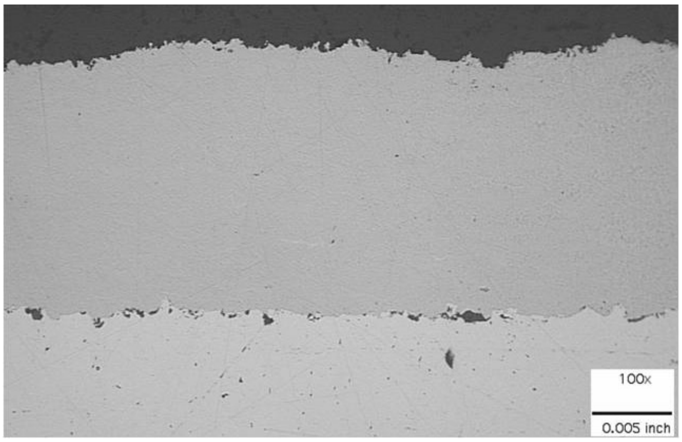
Colmonoy® 88H cannot be hardened by fusing. A Metallurgical bond can be achieved, and coating integrity can be increased by torch, induction or furnace fusing. The fusing temperature is approximately 1065°C (1950°F).

Coatings of Colmonoy® 88H can be ground with silicon carbide or machined with CBN or carbide tooling.

Colmonoy® 88H can be utilised as a chromium plating replacement. The coating is more dense (≥98%) and far less prone to cracking than chrome.

Table 1: Colmonoy® 88 Physical Properties (approximate):

Density	9.89 g/cc
	0.357 lb/cu in
Melting Point	1100°C
	2020°F
Coefficiant of Friction (6 - micro surface finish)	0.1



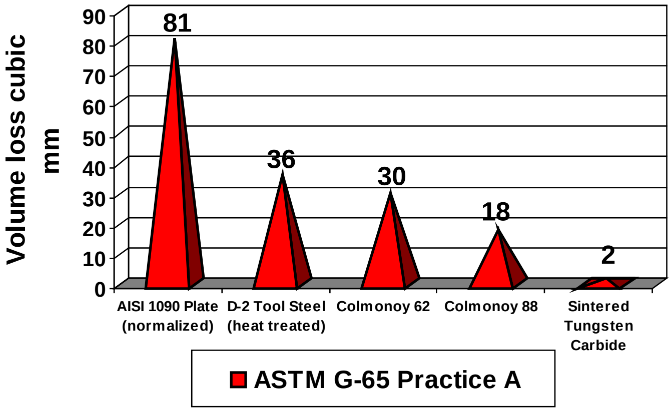
Photomicrograph of Colmonoy® 88HV (original at 100x)

Table 2: Room Temp. Mechanical Properties:
Deposits produced by Spray & Fuse

Compressive strength, (ave.)	275,000 psi
	1,896.06 MPa
Tensile strength, (ave.)	60,000 psi
	413.69 MPa
Charpy impact*, (ave.)	3.0 ft-lb
	4.0 N-m

*Specimens having 12.7mm (1/2-inch) radius notch and polished to remove all possibility of stress concentrations

Table 3: G-65 Dry Sand Abrasion Test



The chart compares abrasive wear test results of several materials under the same conditions. The relatively low volume loss proves the superiority of Colmonoy® 88 to all but the hardest of materials.

Table 4: Colmonoy® 88 Room & Elevated Temp. Hardness:

Deposits produced by Spray & Fuse

Test Temp (°C/ °F)	Rockwell C Hardness
21 / 70	59-64
315 / 600	62
425 / 800	61
540 / 1000	56
650 / 1200	43

Application Methods:

Colmonoy® 88 alloys are easily applied to all steels having less than .25% carbon, grey cast iron; Meehanite, malleable, ingot and wrought iron; nickel, Monel[a] alloy 400, Inconel[a] alloy 600, Nichrome, Chromel[b]. Most high-temperature alloys can be overlaid without special precautions.

Steel having more than .25% carbon can also be overlaid, but requires controlled slow cooling after fusion, in suitable insulation such as Sil-O-Cel, mica, etc. Generally, do not apply to ferrous metals that require subsequent hardening and tempering, because the dimensional change associated with the formation of martensite will crack the deposits of Colmonoy® 88.

Hardenable base metals may be overlayed, but must be annealed isothermally after uniform austenitising to prevent cracking of the deposits of Colmonoy® 88. (Consult Technical Services for further details).

Application by Spraywelder™:

Colmonoy® 88 powder alloys are applied by use of the Spraywelder™, which is the recommended thermal spray system designed by Wall Colmonoy to produce dense coatings. The powder is sprayed on the part to be hard surfaced as in ordinary metal spraying procedure, and the overlay is then fused to the base metal by torch, induction or furnace. This is ideal when deposits of uniform thickness are being applied over a large area. Reference Spraywelder™ Brochure and Manual for more information.

Application by Fusewelder™:

Colmonoy® 88 powder is applied by Fusewelder™ or similar torch. The Fuseweld™ Process is a coating application method to apply metallurgically bonded coatings to the edges and corners of moulds and blanks. Small shafts, the leading edge of flights for augers and centrifuge scrolls, keyways, splines, and cams can all be efficiently coated or rebuilt with this process.

Application by High Velocity Oxygen Fuel Thermal Spray Processes

Table 5: JP 5000 / 8000 Parameters for Spraying Colmonoy® 88H / 88R-H*

Gun barrel:	102mm (4”)
Spray distance:	365mm (14”)
Coating thickness:	>1.5mm (>0.060”)
Spray rate:	4.5 - 5.4kg/hr (10-12 lb./hr.)

Spray Parameters	Supply Pressure	Flow	System Pressure **
Oxygen	210 psi	1925 scfh	140+/-10 psi
Fuel (K1 kerosene)	170 psi	6.0 gph	121+/-10 psi
Powder (nitrogen carrier)	50 psi	19-20 scfh	not applicable
Combustion	N/A	not applicable	103+/-5 psi
Water Temperature: incoming - outgoing -	21°C 50°C+/-5°C		

* Some modifications to the parameters may be needed to compensate for longer hoses.

** System pressures are based on supply pressure and flow settings and are present for the purpose of monitoring the condition system consumables; located at the bottom of the control console.

Table 6: Typical Unfused Coating Characteristics:

Process	JP 5000 / 8000
Macro Hardness HRC **Colmonoy® 88H** **Colmonoy® 88R-H**	 59-64 55-60
Porosity	<2%
Bond Strength	>90 MPa >13,000 psi
Surface Finish **(as sprayed)** **(ground)**	240-300Ra <10Ra
Coefficient of Friction **(6-micro-inch surface finish)**	0.1

Table 7: Hybrid Diamond Jet Parameters with methane (CH_4) for spraying Colmonoy® 88H / 88R-H*

DJ8-9 Powder Injector
DJ2701 Extended Air Cap (1/4" throat)
9MP-DJ Powder Feeder set at 6.0 lb / hr

Spray Parameters	Pressure (psi)	Flow (SCFH)
Air	110	42
Oxygen	150	30
Fuel	110	68

* Some modifications to the parameters may be needed to compensate for longer hoses.

Application by PTA Welding:

There are numerous Plasma Transferred Arc Welding systems on the market and a wide range of welding parameters can be used with Colmonoy® 88 P1 and P2 to produce excellent weld overlays.

Wall Colmonoy recommends that a pure argon plasma gas be used in combination with an argon-hydrogen shielding gas and an argon carrier gas.

Welding parameter settings will depend on the base metal, its thickness, geometry and metallurgical condition as well as the desired properties/geometry of the weld overlay and the type of PTA equipment being used.

Preheat and weld inter-pass temperature can affect the quality of the weld deposit and its wear properties.

Preheat Temperature by Class for steels

Class	Description	up to ½"	½" to 1"	1" to 2"	Interpass
10xx	C steels	100 – 600	100 – 700	100 – 800	200 – 700
13xx	Mn steels	350 – 500	400 – 600	450 – 700	450 – 600
23xx	Ni steels	200 – 400	200 – 500	300 – 700	300 – 600
31xx	Ni – Cr steels	200 – 600	300 – 700	400 – 900	>400
32xx	Ni – Cr steels	300 – 900	400 – 1000	500 – 1100	500 – 900
33xx	Ni – Cr steels	500 – 900	600 – 1000	700 – 1100	700 – 900
34xx	Ni – Cr steels	900 – 1100	900 – 1100	900 – 1100	900 – 1100
4140	Cr – Mo steel	600	700	800	600 – 800
4340		600	800	900	700 – 900
46xx		400 – 600	500 – 700	600 – 800	≅ 600
4820		600	700	800	600 – 800
5120		100 min	200 – 300	250 – 350	≅ 300
5145		400 – 500	450 – 550	500 – 600	≅ 500
86xx		100 – 400	200 – 500	300 – 600	≅ 400
High strength alloy steels (quenched and tempered)					
A533, B		50 – 200	100 – 350	200 – 450	100 – 350
A542		150 – 300	200 – 350	250 – 450	200 – 350
HY-130		75 – 225	75 – 275	200 – 375	200 – 350

Application by Laser Cladding

Laser cladding utilises a laser beam as a heat source to weld a surfacing material to a substrate. Surface cladding powder is delivered to the weld zone through a powder feeder with an inert gas carrier. The power level of the laser, the powder feed rate, pre-heat of the base metal, and 3-dimensional movement speeds must be balanced to produce a metallurgically bonded, low dilution, crack free, porosity free clad overlay.

Properly applied laser clad overlays can have significantly higher hardness than a corresponding thermal spray applied coating of the same material. Alloy selection for the laser cladding process should take this into consideration.

Laser cladding can be conducted in a sealed, inert environment, or in an open shop environment. In the latter case, the use of argon or helium carrier gases with argon and/or helium shielding gases are recommended. Nitrogen is not an inert gas and it is not recommended for general use in Laser Cladding.

Machining, Grinding and Lapping:

There are several techniques used for material removal that produce high quality finished products. Machining can be done, using cubic boron nitride tooling. Use GE's BZN compacts (such as BRNG-43T) or Kennametal's CNMA 433KC-210. Use a negative rake tool, with a 15-degree lead angle. It should have a 1.2mm (3/64-in.) radius and T-land edge preparation. Set tool at centreline of work. Feed at 0.005-0.010 IPR, with depth of cut up to 3.2mm (0.125-in.), at 200-300 SFM or higher.

The coatings can be machined with difficulty by carbide-tipped tools, such as Kennametal K6, Carboloy 883 or equivalent. For roughing, grind the tool with a slight lead and rake angle, and a slight radius (approx. 0.8mm (1/32")). Use a fine feed, about 0.076mm (0.003") per revolution, with a depth of cut about 0.38mm (0.015") at 15 SFPM. Set tool about 0.8mm (1/32") below centre. For finishing, grind the tool with the same slight lead and rake angles and with about a 1.6mm (1/16") radius. Use a fine feed, about 0.076mm (0.003") per revolution, with a maximum cut of 0.13mm (0.005") at approximately 45 SFPM.

Grinding is used after machining to remove the last 0.13 - 0.15mm (0.005-0.006") of material. Actually, the entire finishing is most commonly done by grinding, which eliminates machining. Grinding produces a near-frictionless mirror finish. Such smooth surfaces usually wear better, because they generate less heat and friction. Whereas a diamond wheel is preferred, green silicon carbide wheels (hardness H to K) can be used. Use 24 to 36 grit for roughing and 60 grit or finer for finishing. Grind wet when possible; do not let the wheel get loaded; dress frequently. Take light, fast cuts. (Manufacturer can provide full details for grinding.)

Dry lapping can be used to give the alloy an excellent finish. Silicon carbide, boron carbide and diamond dust are all capable of cutting the Colmonoy® coating, but they must be embedded in a cast iron or steel wheel to properly lap fused deposits of Colmonoy® 88 alloys. Apply with a steady pressure and avoid overheating. If the lapping compounds are used loose, they will cut the nickel matrix before the chromium carbides, giving the surface an etched appearance.

Safety:

When handling powders do so in such a way to avoid creating a dust cloud; avoid inhalation or contact with skin or eyes. Conduct coating operations in a properly ventilated area. For more information, consult 11.8 (Ventilation), *AWS Thermal Spraying: Practice, Theory, and Application* available from American Welding Society, OSHA Safety and Health Standards available from U.S. Government Printing Office, and the manufacturer's Material Safety Data Sheet (MSDS).

Warning: Thermal spray torches and heating torches used for application of this product utilise compressed gases including oxygen and a flammable fuel gas. Follow your employers safety procedures when using and handling these gases and equipment. Infrared and ultraviolet radiation (light) emitted from flame and hot metal can injure eyes and burn skin. Use appropriate personal protective equipment.

Danger: Plasma transferred arc (PTA) welding is a welding process used for application of this product. Follow your employers safety procedures and the equipment manufacturers instructions when PTA welding. Electric shock can kill. Properly install and ground electrical equipment prior to use. Infrared and ultraviolet radiation emitted from the hot metal or welding arc can injure eyes and burn skin. Use appropriate personal protective equipment.

Warning: Laser cladding processes may use high power levels when applying this product. Follow your employers safety procedures and the equipment manufacturers instructions when laser cladding. Refer to AISI Z136.1 "Safe use of Lasers" and consult your employers Laser Safety Officer regarding the proper use of personal protective equipment.

Storage Requirements:

Keep thermal spray powders in a closed container and protect against moisture pick-up. The containers should be tumbled before using the powder. If moisture is absorbed from the atmosphere, it can be removed and flowability can be restored by drying the powder, with the seal removed and lid loosened, at 66°C - 93°C (150°F-200°F) for two hours prior to use.

The information provided herein is given as a guideline to follow. It is the responsibility of the end user to establish the process information most suitable for their specific application(s).

Wall Colmonoy Limited (UK) assumes no responsibility for failure due to misuse or improper application of this product, or for any incidental damages arising out of the use of this material.

a Registered trademark of Special Metal Corporation.
b Registered trademark of Concept Alloys.

updated January 2022