DCHA™
DOWNHOLE COUPON HOLDER ASSEMBLY
User Manual

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PN: 724104-Manual Rev. A

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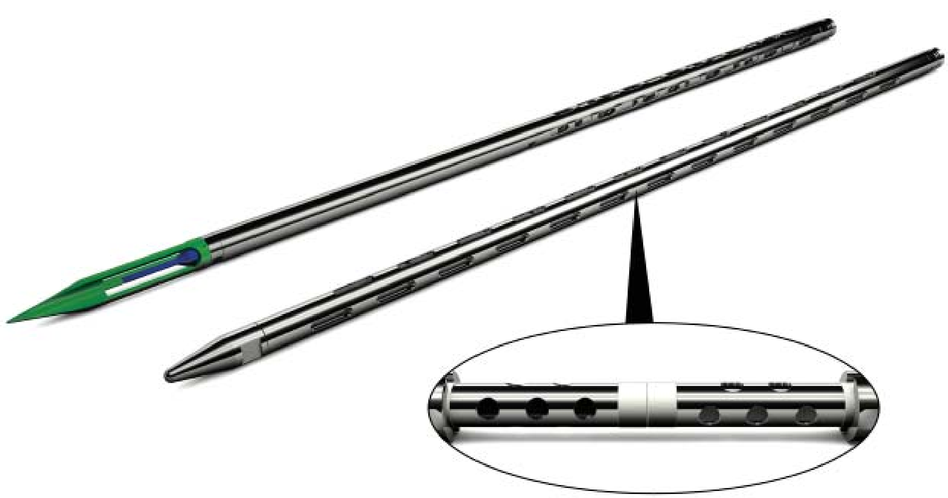
Introduction

CHAPTER 1

The life of a production well is based on many factors. With proper monitoring and maintenance, the integrity of the well, especially the downhole tubing is vital for safety, environmental, and economical reasons. Production wells typically contain water, carbon dioxide, and hydrogen sulphide. This combination of elements along with varying temperatures, creates an extremely corrosive environment, subjecting, the downhole tubing to corrosion damage including metal loss, pitting, and stress corrosion cracking.

The Downhole Coupon Holder Assembly (DCHA) was developed to test the effects of different types of corrosion on downhole tube materials, inlcuding general corrosion, crevice corrosion, stress corrosion, and pitting in downhole conditions.The DCHA holds up to nine coupon holders, including Bent Beam, Strip, and Rod. The three type of coupon holders can be “mixed and matched” according to the type of corrosion effects you are evaluating. The DCHA is normally used conjunction with the DCMS Downhole Tool, but may also be installed separately. If more than nine samples are required, mulitple DCHAs may be mated together.

As with any type of corrosion detection device, coupons may not give absolute definitive answers, but will indicate general corrosion behavior patterns and act as a secondary metal loss measurement, when used in conjunction with the DCMS Downhole Tool. Coupon metal loss data from the DCHA samples can be correlated with ER probe metal loss data and temperature data, from the Downhole tool, to effectively analyze the condition of the downhole tubing.



DCHA shown attached to the DCMS Downhole Tool

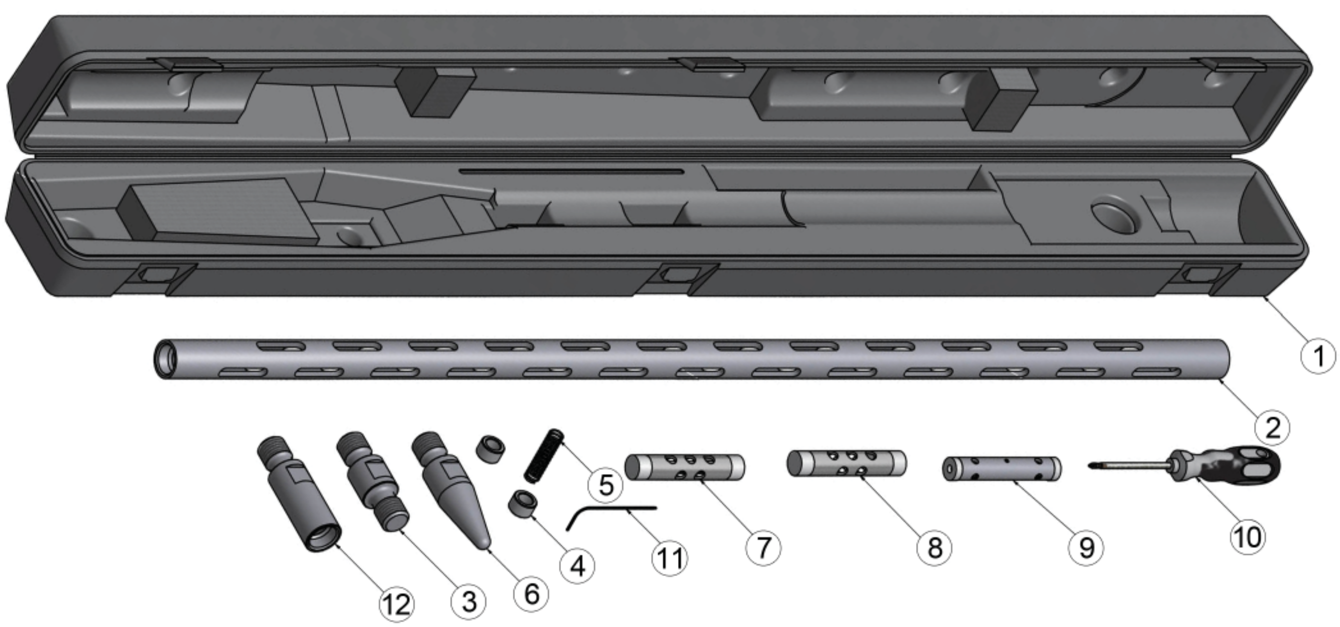
CHAPTER 2

Specification

Environment:	Oil, Gas, Water Production
Temperature:	325°F (163°C) maximum (mated to DCMS Tool)
Pressure:	10,000 psi (69 MPa) maximum
Body Material	316 Stainless Steel
Thread Attachment:	5/8" API Sucker Rod Connection Spec. 11B

The DCHA consists of the following components:

1. Downhole Coupon Holder Case
2. Downhole Coupon Holder Assembly Body
3. 5/8" Sucker Rod Connector
4. Downhole Spring Carrier (2)
5. Downhole Tension Spring
6. Bull-Nose 5/8" Sucker Rod Connector
7. Strip Coupon Holder Assembly
8. Cylindrical Coupon Holder Assembly
9. Bent-Beam Coupon Holder Assembly
10. Phillips Screwdriver
11. 1/16" Hex L-Key
12. 5/8" Pin Sucker Rod to 5/8" Box S.R. Adapter



DCHA Downhole Coupon Holder Assembly

DCHA Cutaway showing the Strip, Rod, and Bent Beam Coupon Holder Assemblies

Types of Coupons

CHAPTER 3

The DCHA coupon holder assembly configuration may vary depending on what corrosion effect you are evaluating. The DCHA can hold up to nine coupon holder assemblies. The three types of coupons available are described below.

Strip Coupons

Strip coupons are standard metal loss coupons and are used for determining corrosion rate and pitting in downhole environments. They are also ideal as secondary metal loss measurement to electrical resistance probes. The specimen is exposed to the environment in a non-stressed coupon holder. The strip coupon holder is designed with non-metallic end caps to isolate the coupon from the body to prevent galvanic corrosion from influencing measurement data.

Cylindrical Coupons

Cylindrical coupons are round tensile specimens to determine the extent of any deterioration in the tensile properties of materials that have been subjected to the downhole environment. The specimen is exposed to the environment in a non-stressed coupon holder. The cylindrical coupon holder is designed with non-metallic end caps to isolate the coupon from the body to prevent galvanic corrosion from influencing measurement data.

Bent-Beam

Bent-Beam Coupons are a variant of the strip coupon, but used with an applied stress – usually at mid-coupon, which bends the coupon. This method is used to test for susceptibility of a material to stress corrosion cracking in downhole environments. The bent-beam coupon holder is designed generally in accordance with the requirements of NACE Standard TM0177-2005. A glass bead and glass tubes are used to isolate the coupon from the body and other metallic parts to prevent galvanic corrosion from influencing measurement data.

CHAPTER 4

Installation

DCHA

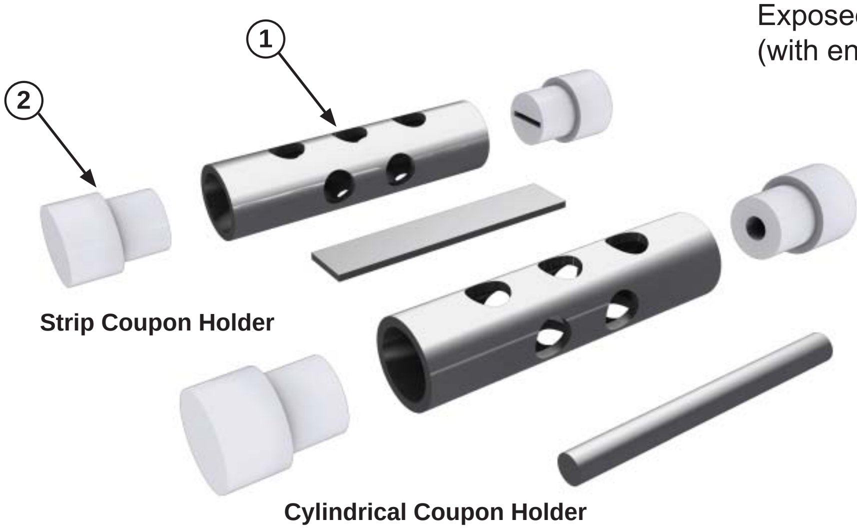
The DCHA comes with the individual coupon holder assemblies installed. If coupons were included, they will be shipped separately and will need to be mounted in the individual coupon holder assemblies.

1. Unscrew and remove one of the sucker rods from the DCHA.
2. Remove the spacer and coupon holder assemblies.
3. Assemble the coupons on the coupon holder assemblies as shown below. Ensure that the coupons are completely insulated from mounting screws, nuts, and coupon holders. **DO NOT HANDLE COUPONS WITH BARE HANDS!** Be sure and use the proper insulation and mounting hardware when assembling the coupons to the coupon holder assemblies.
4. Replace the coupon holder assemblies and spacer into the DCHA body and screw the sucker rod back on.

Strip and Rod Coupon Holder Assemblies

Components:
1. Coupon Holder Body
2. End Cap (2)

Strip Coupon Reference:
Dimensions: 3.00” x 0.19” x 0.50”
Total Area: 4.31 in^2
Exposed Surface Area: 3.63 in^2
(with end caps)

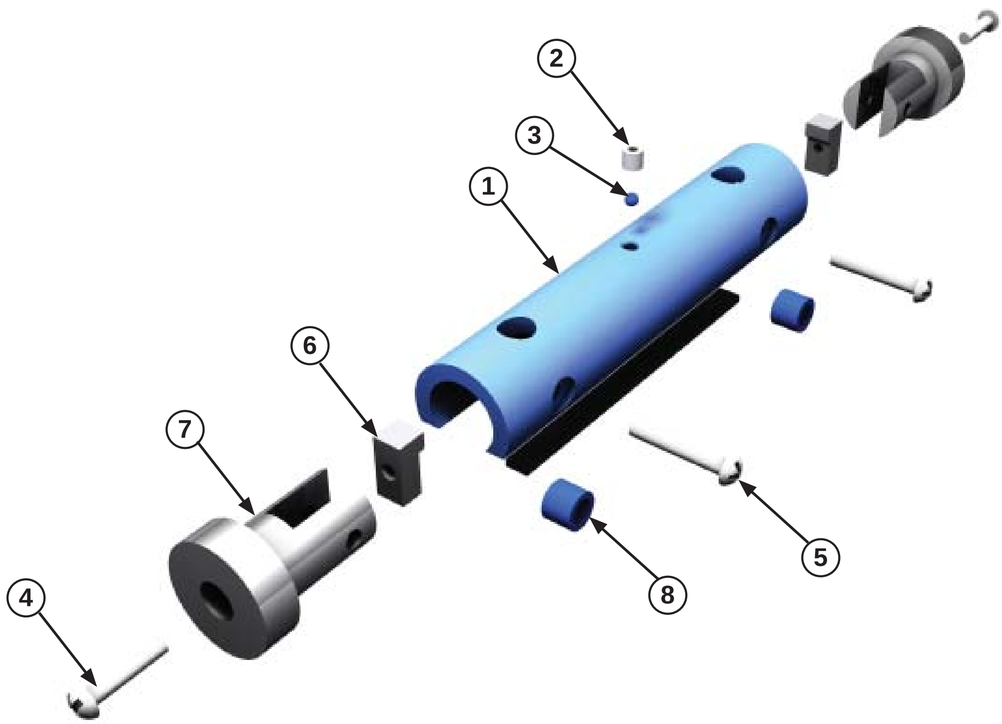


Assembly:
1. Remove one end from coupon assembly body.
2. Insert strip/cylindrical coupon into end cap and insert into coupon assembly body.

Bent Beam Coupon Holder Assembly

Components:

1. Bent-Beam Body Coupon Holder Body (1)
2. Set Screw, 1/8” (1) (extras included)
3. Glass Beads (1) (extras included)
4. Screw, 4-40 x .5” (2)
5. Screw, 4-40 x .68” (2)
6. Bent Beam Guide (2)
7. End Cap (2)
8. Glass Support Tube (2)



Assembly:

1. Glue glass bead to the inset on the 6-32 x 1/8” set screw using the adhesive included.
2. Remove one of the 4-40 x .68” screws and glass tube from the coupon holder body.
3. Insert the bent-beam coupon or specimen under the other screw with glass tube.
4. Re-install glass tube and screw to the coupon holder body.
5. Using the allen key included, install the set screw, making sure that the glass bead is still in place. Use caution not to over tighten the set screw, install slowly to avoid bending specimen.

6. Once specimen has been positioned correctly take an initial depth measurement using a depth gauge or a vernier caliper at the center of specimen. Use the two holes in the center of the specimen as a guide for the location of the measurement.

7. Adjust set screw very slowly using very small turn increments. After each adjustment of the set screw measure the depth to the required dimension based on initial depth measurement. Reference TM0177-20005 and deflect the test specimens to the nearest 0.0025mm (0.00010 in.)

CHAPTER 5

Field Handling and Cleaning of Corrosion Coupons

Field Handling

1. All corrosion coupons must be handled with clean gloves. **NEVER HANDLE WITH THE BARE HAND!** To do so, will assuredly affect the coupon and give false test data due to body oils, salts and other rust promoting matter being deposited on them. Handle coupons carefully to prevent scratching or otherwise marring the surface.

2. All corrosion coupons are weighed to 0.1 milligrams (0.0001 grams), serialized and packaged in moisture-proof envelopes. Coupon weight sheet data which are supplied with each order furnish the specifics of each coupon as to material composition, weight in grams and its identifiable serial number.

3. If on-site field handling conditions prohibit the cleaning procedure described below, the coupons should be placed in the original moisture-proof envelope and shipped to a laboratory immediately for analysis. The corrosion coupon should not be wiped off, coated with grease, or otherwise altered.

Cleaning

1. Photograph coupons, before and after cleaning, if possible.

2. Visually examine coupons and analyze any scale or foreign materials build-up on them.

3. Clean the coupon(s) by immersing in a suitable hydrocarbon solvent, such as clean benzene. Do this long enough to remove any oil or paraffin deposits.

4. Immerse the coupon in fifteen percent (15%) inhibited hydrochloric acid (HCl) for one (1) to two (2) minutes to remove scale or iron oxide. Repeated immersion or a slightly more acidic solution may be required to clean severely coated coupons.

5. Immerse the coupon in saturated sodium bicarbonate ($NaHCO_3$) solution for one (1) minute to neutralize the acid.

6. Rinse the coupon immediately in isopropyl alcohol or acetone to dry. **BE CAREFUL WITH ISOPROPYL ALCOHOL and/or ACETONE!**.....they are volatile flammable solvents.

7. Weigh the coupon to 0.1 milligrams (0.0001 grams). Pit depths may be measured with a depth gauge or micrometer caliper with sharp pointed probes. A microscope calibrated for depth measurement may also be used. (Depth of deepest pit – in mils, inches, or micrometers – times (x) 365 and divided by exposure time in days will give an effective calculation of pitting rate).

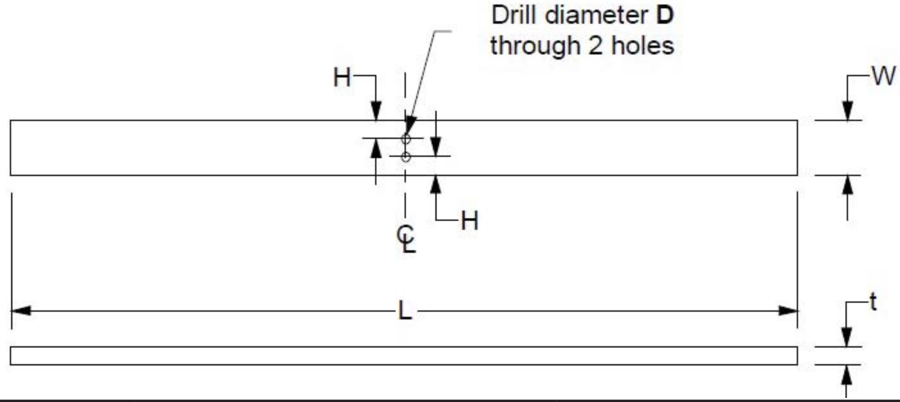
8. Be sure serial numbers are matched; compare weight loss with coupon weight sheet data for differential.

Bent-Beam Coupon Holder Assembly

CHAPTER 6

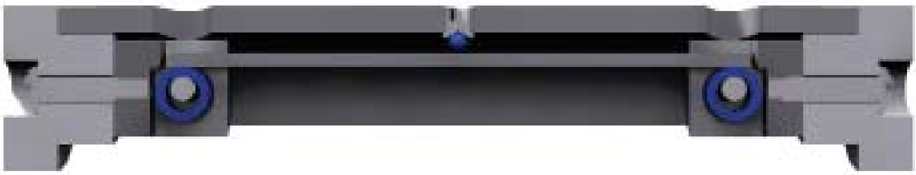
The Bent Beam Coupon Holder Assembly is designed for testing the resistance of downhole tubing to stress corrosion cracking according to NACE TM0177-2005 standard for "Laboratory Testing of Metals for Resistance to SSC and SCC in H2S Environment", Method B - NACE Standard Bent Beam Test. The method is done by using several specimens to which each is subjected to a different bending stress. The stressed test specimens are exposed to the environment (in this case downhole tubing) and the failure or rate of cracking is determined. According to the standard when testing multiple test specimens at varying deflections, a statistically based critical factor (Sc) for a 50% probability of failure can be obtained. The DCHA holds up to nine test fixtures, allowing for an acceptable amount of samples to determine susceptibility to the material cracking failure in downhole environments. Multiple DCHAs can be used if further samples are required.

The test specimens provided by RCS are designed and machined according to the NACE standard. Specimens not provided by RCS should be designed to the specifications noted below.



Dimension	Size	
	(mm)	(in.)
L	67.3 ±1.3	2.65 ±0.050
t	1.52 ±0.13	0.060 ±0.0050
W	4.57 ±0.13	0.180 ±0.0050
H	1.58 ±0.05	0.062 ±0.002
D	0.062 ±0.002	0.028 ±0.0005 (No. 70 Drill)

Dimensional Drawing of the Standard Bent-Beam Test Specimen



Cutaway of Bent Beam Coupon Holder With Coupon Installed

For further details on the standard Bent-Beam test specimens, deflection calculations, and testing method, reference NACE Standard TM0177-2005.

Corrosion Coupon Weight Loss Measurement

CHAPTER 7

(Refer NACE Standard TM-01-69 and RP-07-75):

The use of any criteria in determining corrosion rates or weight loss requires judgment on the part of the user and should be tempered by economic and safety requirements. Some rate expressions assume a uniform loss of metal. Experience has shown that coupons rarely exhibit a uniform loss of metal. Variables on the coupon surface in the form of pitting, and/or localized concentrated corrosion along grain boundaries, or in transgranular paths usually appear.

In determining weight loss there are a number of ways of expressing measurements. The ultimate goal of any way of expressing weight loss or corrosion rate is to have a readily definable and communicable way of determining and expressing the amount of metal or alloy that has corroded or been "eaten away" by the corrosion process.

The following are some of the commonly used methods to report or express corrosion rate data:

1. General Corrosion Rate (Table 1).
2. Average Corrosion Rate (Table 2).
3. Percent Change (Table 3).
4. Engineering System (mils-per-year – Table 4).
5. Metric System (mdd or milligrams per square decimeter per day – Table 5).
6. Pitting Rates (Table 6).

TABLE 1 - GENERAL CORROSION RATE CLASSIFICATIONS	
Classification	**Expression**
Poor (sample shape and exposure time influence results)	Percent weight change
Good (Expressions do not give penetration rates)	Milligrams per square decimeter per day (mdd) Grams per square decimeter per day Grams per square centimeter per day Grams per square meter per hour Grams per square inch per hour
Better (Expressions give penetration rates)	Inches-per-year (ipy) Inches-per-month Millimeters-per-year (mmpy)
Best (Expresses penetration rates without decimals or large numbers)	Mils-per-year (mpy) – Is equivalent to one thousandth of an inch per year

TABLE 2 - AVERAGE CORROSION RATE CLASSIFICATIONS				
Classification	**Average Corrosion Rate**		**Average Pitting Rate**	
	mpy	µm/a	mils/yr	µm/a
Low	1.0	25	12	305
Moderate	1.0 - 4.9	25 - 125	12 - 24	305 - 610
Severe	5.0 - 10.0	126 - 254	25 - 96	635 - 2438
Very Severe	10.0 -	254 -	96 -	2438 -

mpy = mils-per-year (one thousandth of an inch per year or 0.001”)
µm/a = micrometers per annum (one thousandth of a millimeter per year or 0.000001; is equivalent to 0.04 mpy)

TABLE 3 - PERCENT CHANGE
Original Value minus Final Value Divided by Original Value……X 100 = Percent weight change

TABLE 4 - ENGINEERING SYSTEM
Commonly used unit of corrosion rate expression measuring Dimensional Change or Loss of Metal Thickness per Unit Time and referred to as mils-per-year (mpy). A mil is one thousandth of an inch or 0.001”; if multiplied by 1000 is the same as inches-per-year or (ipy).
Formula 1: $mpy = \frac{534 \times W}{DAT}$ W = Weight loss in milligrams D = Density of coupon in grams divided by cubic centimeters (g/cm^3) A = Area of coupon in square inches (in^2) T = Time exposed in hours
Formula 2: mpy = $\frac{\text{Weight loss of coupon (g) x 1000 (mils/in) x 365 (days/yr)}}{\text{Density of metal } (g/cm^3) \text{ x 16.4 } (cm^3/in^3) \text{ x area } (in^2) \text{ x days exposure}}$
or The weight loss of the corrosion coupon divided by the quantity of the product of the metal density, the total exposed surface area (including sides) and the exposure time.

TABLE 5 - METRIC SYSTEM	
Commonly used unit of corrosion rate expression measuring Weight Change or Weight Loss or Gain per Unit Area per Unit Time and referred to as milligrams per square decimeter per day or “mdd”. A milligram is one thousandth of a gram; a decimeter is 10 centimeters or almost four inches. If mdd is multiplied by 0.03652/D (D = density in grams per cubic centimeter or g/cm^3) it is the same as millimeters per year or “mmpy”.	
Formula 1: $mmpy = \frac{87.6 \times W}{DAT}$	W = Weight loss in milligrams; D = Density of coupon in grams divided by cubic centimeters (g/cm^3); A = Area in square centimeters (cm^2); T = Time exposed in hours
Formula 2: mdd = $\frac{\text{Weight loss coupon (g) x 1000 (=mg) x 100 } cm^2 \text{ } (=dm^2)}{\text{Area } (cm^2) \text{ x exposure time in days}}$	

TABLE 6 - PITTING RATES
Pit depths may be measured with a depth gauge or micrometer caliper with sharp pointed probes. A microscope calibrated for depth measurement may also be used. Depth of deepest pit in mils, inches or micrometers times (x) 365 and divided by exposure time in days will give an effective calculation of pitting rate.

Conversion Factors and Metal Densities

CHAPTER 8

COMMON METAL ALLOYS AND THEIR DENSITIES							
Aluminum Alloy	g/cm^3	Copper Alloys (cont'd)	g/cm^3	Ferrous Metals	g/cm^3	Nickel Alloys	g/cm^3
1100, 3004	2.72	Cartridge brass 260	8.52	Gray cast iron	7.20	Nickel 200	8.89
1199, 5005, 5357, 6061,		Muntz metal 280	8.39	Carbon Steel	7.86	Monel Alloy 400	8.84
6062, 6070, & 6101	2.70	Admiralty 442, 443,		Silicon iron	7.00	Inconel Alloy 600	8.51
2024	2.77	444 & 445	8.52	Low alloy steels	7.85	Incoloy Alloy 825	8.14
2219, 7178	2.81	Aluminum brass 687	8.33	Stainless steels:		Hastelloy B	9.24
3003, 7079	2.74	Bronzes:		201, 202, 302, 304,		" C	8.93
5050	2.69	Aluminum bronze 5% 608	8.16	304L & 321	7.94	" G	8.27
5052 & 5454	2.68	Aluminum bronze 8% 612	7.78	309, 310, 311, 316,			
5083, 5086, 5154, &		Composition M	8.45	316L, 317, 329, & 330	7.98	Other Metals	
5456	2.66	Composition G	8.77	347	8.03	Silver	10.49
7075	2.80	Phosphor bronze 5% 510	8.86	410	7.70	Tantalum	16.60
		" " 10% 524	8.77	430	7.72	Tin	7.30
Copper Alloys		85-5-5-5	8.80	446	7.65	Titanium	4.54
Copper	8.94	Silicon bronze 655	8.52	502	7.82	Zinc	6.52
Brasses:		Copper Nickels 706, 710		Durimet 20	8.02		
Commercial brass 220	8.80	& 715	8.94	Carpenter 20 Cb 3	8.05		
Red Brass 230	8.75	Nickel Silver 752	8.75				

SHORT FORM CONVERSION FORMULAS To get mpy and/or mdd:		
Multiply	**By = mpy**	**By = mdd**
Grams per square inch per hour	536,300.0/D*	372,000.0
“ “ “ “ day	22,270.0/D*	15,500.0
“ “ “ “ year	61.0/D*	42.5
“ “ centimeter per hour	3,460,000.0/D*	2,400,000.0
“ “ “ “ “ day	143,700.0/D*	100,000.0
“ “ “ “ “ year	394.0/D*	274.0
“ “ meter per hour	346.0/D*	240.0
“ “ “ “ day	14.37/D*	10.0
“ “ “ “ year	0.0394/D*	0.0274
Ounces “ “ inch per day	632,160.0/D*	439,200.0
“ “ “ foot “ “	4,390.0/D*	3,052.0
Centimeters per year	394.0	274 x D*
Millimeters “ “	39.4	27.4 x D*
Inches per year	1,000.0	696.0 x D*
Mils-per-year	-------------	0.696 x D*
Milligrams per square decimeter per day	1.437/D*	------------
Note: D* is density of metal in grams per cubic centimeter-g/cm^3		

CONVERSION FACTORS		
To obtain	**Multiply**	**By**
Grams per square inch per hour	Milligrams per square decimeter per day (mdd)	0.00000269
Grams per square meter per day	“	10.0
Grams per square meter per year	“	36.5
Inches per year	“	0.00144/D*
Milligrams per square decimeter per day	Grams per square inch per hour	372000.0
“	Grams per square meter per year	0.0274
“	Pounds per square foot per year	133.8
Milligrams per square decimeter	Ounces per square foot	3052.0
Millimeters per year	Milligrams per square decimeter per day (mdd)	0.03652/D*
“	Grams per square meter per day	0.36525/D*
“	“	365.25/D#
“	Inches per year	25.4
Ounces per square foot	Milligrams per square decimeter	0.0003277
Pounds per square foot per year	Milligrams per square decimeter per day	0.00748
Note: D* is density of metal in grams per cubic centimeter (g/cm^3) D# is density of metal in kilograms per cubic meter (kg/m^3)		