
COSASCO TWO-INCH SYSTEM INSTALLATION, OPERATION & MAINTENANCE MANUAL

CORROSION COUPONS (Alloy Specimens) & COUPON HOLDER ASSEMBLIES

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P/N 740075 Rev. -

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Chapter 1

Introduction

Corrosion coupons are one of the longest used methods for the study of corrosion and its effects. They are relatively small, easily inserted and retrieved, and are an economical means of determining cause and effect of corrosion.

As with any type of corrosion detection device, coupons may not give absolute definitive answers, but will indicate general corrosion behavior patterns. They may be used in conjunction with other means of corrosion monitoring devices developed for specific and peculiar types of corrosion (for example; galvanic, pH, thermal, etc.).

For best results, the interpretation of the results should take into consideration the location and orientation of exposure, the composition of product media and other variables.

Chapter 2

General

It is important to remember that coupons indicate the attack of the environment only at the point of exposure. Therefore, coupons should be installed as closely as possible to the point where surveys are desired. That is, near pipe wall surfaces, vessel surfaces, tube sheets, trays, up-stream of major tie-ins; and in areas of turbulence, changes in velocity and temperature. The single or combined effect of the product environment temperature, solution concentration, agitation, aeration, pH, velocity and bacteriological attack will also affect the coupons. To the degree that each of these can be considered in relation to each other and entered into the interpretation of the results, the more beneficial the coupon corrosion rate data will be.

Chapter 3

Types of Corrosion Coupons

(Refer to Figure 1):

Coupon material may be as varied as line or containing vessel material. The most widely used material is mild or low carbon steel, such as AISI-1018.

Additionally, coupon configuration may be quite varied depending upon their application. Ideally, the ratio of area to material density and total area to edge area should be large. Several types of coupons and a brief description of each follow:

Strip Coupons (Single or Ladder):

Generally used in nominal lengths of 2", 3", 4" or 6" (50.8 mm, 76.2 mm, 101.6 mm or 152.4 mm, respectively); .875" (22.23 mm) wide; and .125" (3.18 mm) thick. For particular applications almost any size may be utilized, provided it is installable and retrievable within the parameters of the Cosasco Access Fitting Assembly and its compatible Retriever and Service Valve hook-up. Strip coupons are probably the most popular type of coupon. Of the varying types of coupons available, they are generally the most economical, provide satisfactory corrosion rate data; unless particular problems are encountered in the application (e.g., pigging or orientation) are very adequate.

Disc Coupons (Adjustable, Single or Multiple):

Generally of 1.25" diameter and .125" thick (31.75 mm and 3.18 mm). Other sizes may be utilized provided coupons are installable and retrievable within the parameters of the Cosasco Access Fitting Assembly and its compatible Retriever and Service Valve Hook-up.

Disc Coupons are particularly useful for multiple phase flow, as separation due to gravity will expose certain disc coupons to varying degrees of environment corrosiveness, depending upon the stratification encountered in the product flow. When they are used singly and mounted flush with pipe ID surfaces they offer the advantage of not having to be retrieved from the line for pigging operations. Also, orientation with product flow is not required.

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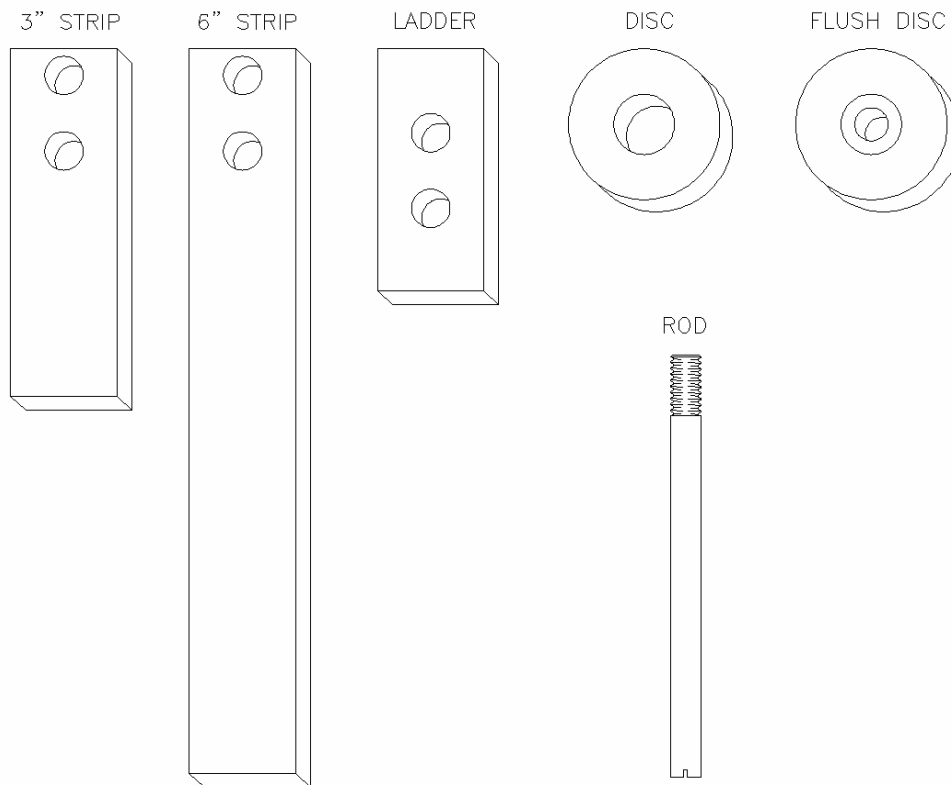


FIG. 1

TYPICAL COUPONS

Rod Coupons (Single or Multiple):

Rod Coupons are normally of 3" length and of .25" diameter (76.5 mm and 6.4 mm). As with other coupon types, rod coupons are available in other sizes provided they are installable and retrievable within the parameters of the Cosasco Access Fitting Assembly and its compatible Retriever and Service Valve hook-up.

Rod coupons may be attached to their holder singly; however, they are usually used in groups of two (2) to five (5) to a holder. An advantage may be obtained if they are replaced sequentially; (i.e., one (1) or two (2) changed each month or periodically, with comparisons made in the intervening exposure times).

Prestressed (Single or Multiple) and Basket Coupons:

Prestressed Coupons are a variant of the strip coupon, but with an applied stress – usually at mid-coupon, which bends the coupon(s). This type measures the effect of the stress on the susceptibility to corrosion and can monitor the success of treatments to control stress corrosion.

Basket Coupons are a variant of the prestressed coupon, but non-insulated from its small stainless steel mesh basket container, which prevents loss of the coupon to the product flow stream.

Chapter 4

Field Handling and Cleaning of Corrosion Coupons

(Refer NACE Standard RP-07-75):

A. 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 Cosasco 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.

B. 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.

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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.

Chapter 5

Coupon Holder Assemblies

(Refer to Figure 2):

IMPORTANT NOTE: If fitting of corrosion coupons to coupon holder assemblies or coupon holder assemblies to solid plug assemblies is being conducted on lines where installation and retrieval are to be done under pressure; first, see Manual P/N: 600000-MANUAL – Retriever and Service Valve Manual, and in particular Section 5 thereof!

All Cosasco Coupon Holder Assemblies attach to the bottom of the solid plug assembly in the same manner. Procedures for their attachment are as follows:

1. Unscrew and remove the solid plug assembly from the access fitting body.
2. Loosen the anti-vibration Allen head set screw on the bottom of the solid plug assembly. The set screw is the locking device on the solid plug nut. The solid plug nut acts as a primary packing retainer until a corrosion monitoring or preventing device is attached.
3. Remove the solid plug nut from the bottom of the solid plug assembly. (Note that this is a left-hand threaded nut).
4. Attach the coupon holder assembly on the exposed threads at the bottom of the solid plug assembly, while leaving the primary packing in place. Again, remember that it is left-hand threaded.
5. Compress the coupon holder assembly against the primary packing by tightening up to not more than 1/4 turn after making initial contact with the packing.
6. Lock the coupon holder assembly securely to the solid plug assembly by tightening the anti-vibration Allen head set screw.
7. Assemble the coupons on the coupon holder assembly. (Some special coupons and their holders, such as prestressed and basket, are already assembled to their respective holders when they are received from the factory).

Ensure that the coupons are completely insulated from mounting screws, nuts, and coupon holders. **AGAIN, DO NOT HANDLE COUPONS WITH THE BARE HAND!** Be sure and use the proper insulation and mounting hardware when assembling the coupons to the coupon holder.

Cosasco mounting hardware (for all single disc coupons this is actually a Nylon screw) is furnished with the coupon holder assembly. Insulation strips and bolt hole shoulders for all strip coupons are furnished with the coupons. Insulation discs, o-rings and coupon-to-coupon spacers for all multiple disc coupons are furnished with the multiple disc coupon holder assembly.

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8. Index the hex head of the solid plug assembly by making a reference mark to indicate the position or orientation of the coupon placement. This can be done either by center-punching an indentation or by filling a notch across the hex head of the solid plug assembly assuring alignment with the narrow edge of the strip coupon. (Not a required procedure for disc coupon holder assemblies, since their positioning is in the horizontal plane in relation to product flow).

9. The coupon holder assembly, with its attendant coupons, is now ready for installation into the access fitting body. Remember!...IF INSTALLATION IS TO BE ON LINES OR VESSELS WHILE THEY ARE OPERATING UNDER PRESSURE, see Manual 600000-MANUAL – Retriever and Service Valve Manual, Section 5.

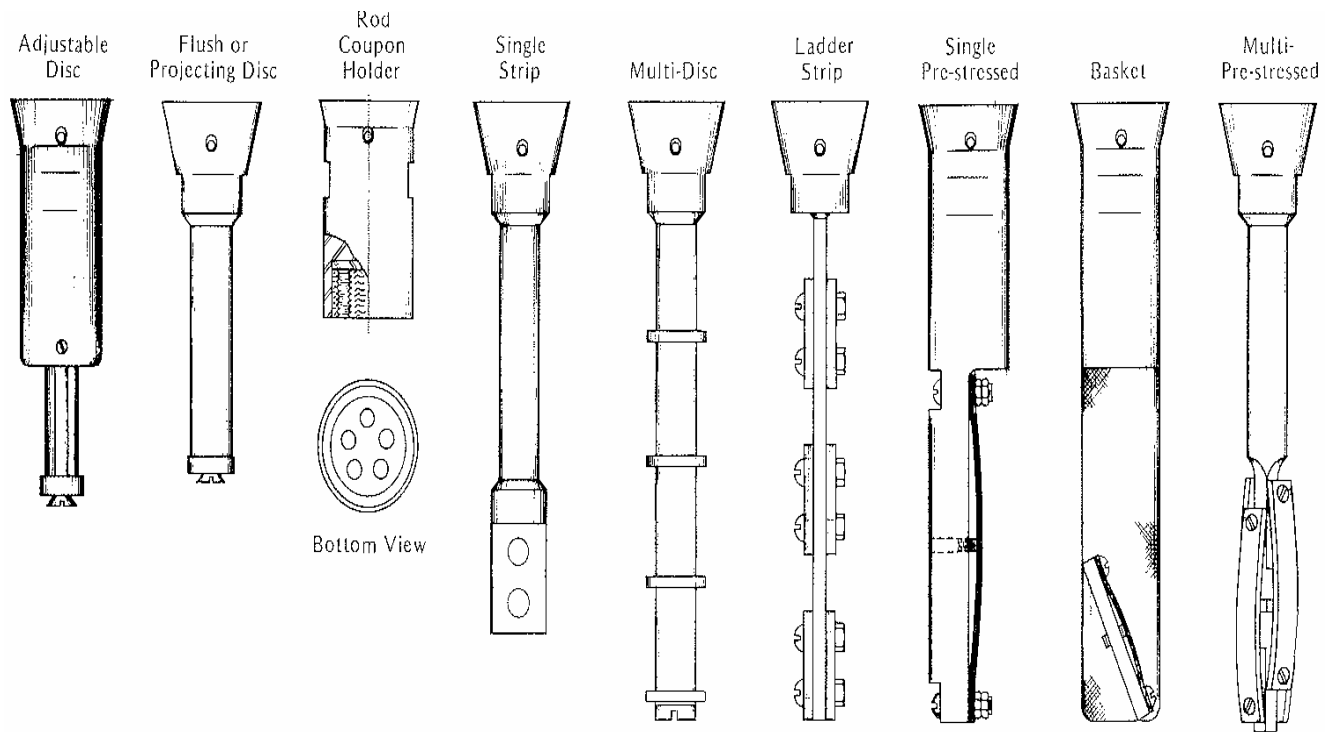


FIG. 2

TYPICAL COUPON HOLDERS

Chapter 6

Corrosion Coupon Positioning & Orienting

Strip coupons require orientation. They should be exposed narrow edge in line with product flow or so that the broad face of the strip coupon does not confront the product flow. Rod coupons may, or may not, require orientation depending upon the number of rod coupons used in a single application. Disc coupons do not require orienting for reasons indicated in paragraph 8 of the preceding section.

Chapter 7

Corrosion Coupon Weight Loss Measurement

(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 (Figure 3).
2. Average Corrosion Rate (Figure 4).
3. Percent Change (Figure 5).
4. Engineering System (mils-per-year – Figure 6).
5. Metric System (mdd or milligrams per square decimeter per day – Figure 7).
6. Pitting Rates (Figure 8).

FIG. 3 GENERAL CORROSION RATE CLASSIFICATIONS	
Classification	Expression
<u>Poor</u> (sample shape and exposure time influence results)	Percent weight change
<u>Good</u> (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
<u>Better</u> (Expressions give penetration rates)	Inches-per-year (ipy) Inches-per-month Millimeters-per-year (mmpy)
<u>Best</u> (Expresses penetration rates without decimals or large numbers)	Mils-per-year (mpy) – Is equivalent to one thousandth of an inch per year

FIG. 4 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)

FIG. 5 PERCENT CHANGE
Original Value minus Final Value Divided by Original Value.....X 100 = Percent weight change

FIG. 6 ENGINEERING SYSTEM
Commonly used unit of corrosion rate expression measuring <u>Dimensional Change</u> or <u>Loss of Metal Thickness</u> per <u>Unit Time</u> 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: $mpy = \frac{534 \times W}{DAT}$ <div style="display: inline-block; vertical-align: top; margin-left: 20px;"> W = Weight loss in milligrams D = Density of coupon in grams divided by cubic centimeters (g/cm³) A = Area of coupon in square inches (in²) T = Time exposed in hours </div>
Formula 2: $mpy = \frac{\text{Weight loss of coupon (g)} \times 1000 \text{ (mils/in)} \times 365 \text{ (days/yr)}}{\text{Density of metal (g/cm}^3\text{)} \times 16.4 \text{ (cm}^3\text{/in}^3\text{)} \times \text{area (in}^2\text{)} \times \text{days exposure}}$
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.

FIG. 7	<u>METRIC SYSTEM</u>
<p>Commonly used unit of corrosion rate expression measuring <u>Weight Change</u> or <u>Weight Loss</u> or <u>Gain</u> per <u>Unit Area</u> per <u>Unit Time</u> 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/cm³) it is the same as millimeters per year or “mmpy”.</p>	
<p>Formula 1: $mmpy = \frac{87.6 \times W}{DAT \times D}$ W = Weight loss in milligrams; D = Density of coupon in grams divided by cubic centimeters (g/cm³); A = Area in square centimeters (cm²); T = Time exposed in hours</p>	
<p>Formula 2: $mdd = \frac{\text{Weight loss coupon (g)} \times 1000 (=mg) \times 100 \text{ cm}^2 (=dm^2)}{\text{Area (cm}^2) \times \text{exposure time in days}}$</p>	

FIG. 8	<u>PITTING RATES</u>
<p>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.</p>	

Chapter 8

Charts and/or Tables –

Useful Conversion Factors and Metal Densities

FIG. 9 COMMON METAL ALLOYS AND THEIR DENSITIES

<u>Aluminum Alloy</u>	<u>g/cm³</u>	<u>Copper Alloys (cont'd)</u>	<u>g/cm³</u>	<u>Ferrous Metals</u>	<u>g/cm³</u>	<u>Nickel Alloys</u>	<u>g/cm³</u>
1100, 3004	2.72	Cartridge brass 260	8.52	Gray cast iron	7.20	Nickel 200	8.89
1199, 5005, 5357, 6061, 6062, 6070, & 6101	2.70	Muntz metal 280	8.39	Carbon Steel	7.86	Monel Alloy 400	8.84
2024	2.77	Admiralty 442, 443, 444 & 445	8.52	Silicon iron	7.00	Inconel Alloy 600	8.51
2219, 7178	2.81	Aluminum brass 687	8.33	Low alloy steels	7.85	Incoloy Alloy 825	8.14
3003, 7079	2.74	Bronzes:		Stainless steels:		Hastelloy B	9.24
5050	2.69	Aluminum bronze 5% 608	8.16	201, 202, 302, 304, 304L & 321	7.94	“ C	8.93
5052 & 5454	2.68	Aluminum bronze 8% 612	7.78	309, 310, 311, 316, 316L, 317, 329, & 330	7.98	“ G	8.27
5083, 5086, 5154, & 5456	2.66	Composition M	8.45	347	8.03	<u>Other Metals</u>	
7075	2.80	Composition G	8.77	410	7.70	Silver	10.49
<u>Copper Alloys</u>		Phosphor bronze 5% 510	8.86	430	7.72	Tantalum	16.60
Copper	8.94	“ “ 10% 524	8.77	446	7.65	Tin	7.30
Brasses:		85-5-5-5	8.80	502	7.82	Titanium	4.54
Commercial brass 220	8.80	Silicon bronze 655	8.52	Durimet 20	8.02	Zinc	6.52
Red Brass 230	8.75	Copper Nickels 706, 710 & 715	8.94	Carpenter 20 Cb 3	8.05		
		Nickel Silver 752	8.75				

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FIG. 10 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/cm³

FIG. 11 <u>CONVERSION FACTORS</u>		
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)		