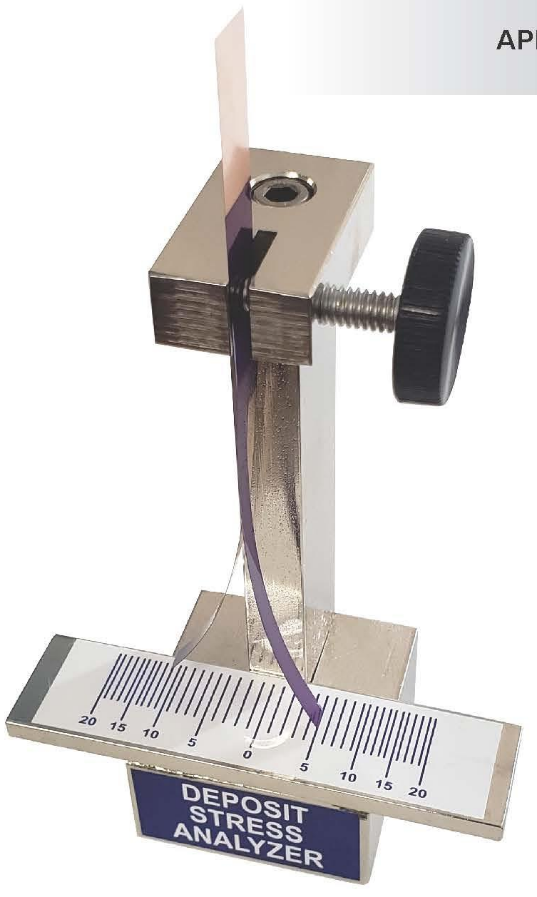
DEPOSIT STRESS ANALYZER

Prevent Deposit Flaking Before It Occurs

This process is approved as ASTM Standard B975.

A STRESS MEASUREMENT METHOD APPLICABLE FOR THIN METALLIC COATINGS



- ECONOMICAL TO USE
- RAPID DETERMINATIONS
- ACCURATE RESULTS
- PRECALIBRATED TEST STRIPS
- SMALL SAMPLE SURFACE AREA
- SMALL ELECTROLYTE VOLUME
- EASY CALCULATION

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DEPOSIT STRESS

Internal stress exists as an inherent force within electroplated and chemically applied metallic coatings. This induced stress can be tensile or compressive in nature, causing the deposit to contract or expand in relation to the base material. High levels of stress in deposits produce micro-cracking and macro-cracking in the applied layers. Severe cases produce a lack of deposit adhesion in the form of blistering, peeling, flaking, wave-like ripples in electroforms, accelerated corrosion and wear failure.

EQUIPMENT DESCRIPTION

The Deposit Stress Analyzer (DSA) System is comprised of an economical, disposable Test Strip, a selection of Plating Cells, and Deposit Stress Analyzer Measurement Stand. The Test Strip has a small surface area, that can be plated in a plating tank or in a laboratory setting using an appropriate Plating Cell. The Cell offers a standard anode to cathode spacing to ensure uniform current density across the Test Strip legs. After plating, the Test Strip is placed on a Measurement Stand to measure in increments the distance that the Test Strip leg tips have spread. The distance is included in a formula to calculate the deposit stress in pounds per square inch. Stress is also determined to be compressive or tensile in nature. Small permanently mountable in tank plating cells are also available.

The DSA Stand supports the plated Test Strip over the measuring scale to read the number of scale increments between the tips of the Test Strip legs. The increment reading can then be included in a formula to calculate the internal deposit stress in pounds per square inch.

TEST EQUIPMENT *(See pages 6 and 7)*

All Specialty Testing equipment is designed for 120 Volt

PN: 800L, 800PVC, 785A, 785C, or 492 Plating Cell

PN: 3046 Electric Immersion Heater

PN: 683 Deposit Stress Analyzer Stand

PN: 15030-D Power Supply
or a constant current/constant voltage power supply with low ripple.

PN: 1194 Series or 270 Series Test Strips

Temperature Controller

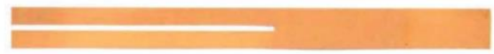
GraLab Timer 60 Minutes*
or equivalent with automatic shut off.

Two Anodes 2 3/8 x 2 3/8 x 1/8 inch*

** Can be purchased from Kocour Company, 4800 South St. Lewis Avenue, Chicago, IL 60632, 1-773-847-1111).*

TEST STRIPS *(Sold in lots of 25 pcs.)*

The Test Strips are made from metals that have spring like properties. However, handle them with care. Bends and dents in the legs will effect the test. They are applicable for all acidic and most alkaline plating chemistries, but not in certain high cyanide solutions.



PN: 1194 Series

PN: 270 Series

** Resist colors may vary.*

PN: 1194 Series Test Strips are made from Copper-Iron Alloy material 0.002 inch thick for deposit stress determinations between 1,500 – 145,000 psi tensile or compressive stress.

PN: 270 Series Test Strips are made from pure Nickel 0.0011 inch thick having particular application for low internal deposit stress values. It is ideal for nickel, electroless nickel, nickel alloys, chromium, tin, silver, gold, palladium, platinum, and rhodium. These Test Strips measure a range of 200-60,000 PSI tensile or compressive stress, making them the most sensitive Test Strip available.

Photo A, Plating set up.

ANALYZER SYSTEM

TEST STRIP AND ANODE CONSIDERATIONS

Metallic Deposit	Test Strip	Anodes*
Cadmium	1194, 270	Cadmium
Chromium	270	Lead
Cobalt	1194, 270	Cobalt
Copper	1194, 270	Copper
Gold	270	Platinum Coated Titanium
Nickel	1194, 270	Nickel
Palladium	1194	Platinum Coated Titanium
Platinum	270	Platinum
Rhodium	270	Platinum Coated Titanium
Silver	1194, 270	Silver
Tin	1194, 270	Tin
Zinc	1194, 270	Zinc

** Two Andodes 2 3/8" x 2 3/8" x 1/8", similar in composition, shape and size. Purchased from Kocour Company.*

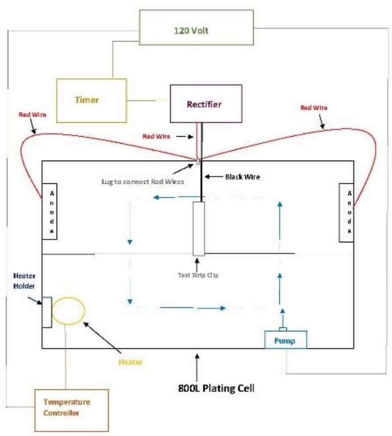


Photo B

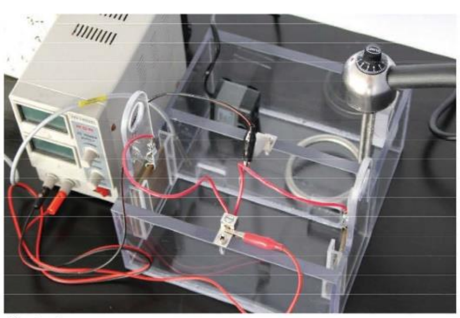


Photo C

DEPOSIT STRESS ANALYZER (DSA)
TEST PROCEDURES FOR TEST STRIPS

(Test Strips PN: 1194, and 270)

Any deposited metallic coating can be tested for stress using the DSA Method. Note that this Test Strip material is applicable for both tensile and compressive stressed deposits. A Wood's Nickel Strike may be required for chemically applied coatings.

1. TEST SET-UP

1. Plug the rectifier into the automatic timer, which is plugged into a 120 Volt source.
2. Place the anodes in the plating cell anode pockets and connect the red leads to the anodes (If using the 785 series plating cell skip to Step #5)
3. Place the heater in the 800 series plating cell (see photos B & C).
4. Set the pump to its lowest setting. Dampen the suction cups on the submersible pump and fasten it to the side of the cell so it rests on the cell bottom with its side located ½ inch from the cell end wall and the outlet directed toward the cell wall opening (see photos B & C). Agitation in the plating side of the cell must be limited to prevent the Test Strip legs from swaying to favor one anode over the other (see photos above).
5. Fill the cell with the plating bath solution to within 1/2 inch or 1.25 cm of the top of the cell (If using the 785 cells skip to step #8).
6. Plug the heater into the temperature controller. Plug the pump and the temperature controller into a 120 Volt source (for the 800 series plating cell).
7. Heat the plating solution to the operating temperature (for the 800 series plating cell).
8. Connect the red positive lead from the power supply to the aluminum lug contact provided on the cell.
9. After following the Test Strip procedure (#2) you will then use the black negative lead to fasten a Test Strip to the stainless steel support mounted on the cell.

2. TEST PROCEDURE

1. Using a sample Test Strip that has been used before, turn on the power supply and adjust to the desired amperage. Then remove the sample Test Strip, and reset the timer.
2. Starting with a new Test Strip, dip in a soak cleaner solution, then water rinse, (Cleaner: 1ml soap to 1 liter of water) to remove finger oils.
3. Immerse Test Strip in a 10% by volume hydrochloric acid solution (9 H_2O + 1 HCl) for 15 seconds at room temperature then water rinse. Dry completely and weigh the Test Strip. Record the starting weight. SW=_____________
4. Turn the agitation pump ON and set the timer for the appropriate plating time.
5. Clip the weighed Test Strip to the stainless steel cross support so the Test Strip is centered between the cell walls. The Test Strip leg tips should be approximately 1/16 of an inch or 3mm from the bottom of the plating cell.
6. Begin the plating test.
7. If the rectifier is plugged into the timer it will end the plating cycle.
8. After the Test Strip is plated remove the Test Strip from the cell.
9. Rinse the Test Strip in water.
10. Lay the Test Strip on a paper towel and gently blot it completely dry.
11. Center the Test Strip on the DSA Stand. Read and record the total increments spread on both sides of the zero as the value for U

    (Example 2.4 +3.1 = 5.5). U= ___________________
12. Weigh the plated Test Strip and record the final weight. FW=_________________
13. Subtract the starting weight from the final weight and the difference = W value in the T= formula. FW-SW=W

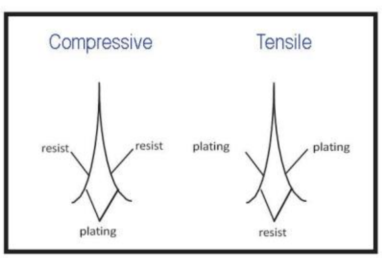


Photo D

The deposit stress is compressive (–) if the resist is on the outside of the Test Strip legs.

The deposit stress is tensile (+) if the plating is on the outside of the Test Strip legs.

3. TEST STRIP CALCULATIONS

Standard English Measurement

It is necessary to know the total units of increments spread (U) between the plated Test Strip leg tips from both sides of the center line on the measuring scale and the average deposit thickness in order to calculate the deposit stress. If the deposit thickness cannot be determined by actual measurement before and after plating, it can be calculated as follows:

$$T = \frac{W}{D\ (7.74\ cm^2)\ (2.54\ cm\ /\ inch)} = \text{Inches}$$

T = deposit thickness in inches
W = deposit weight in grams
D= Density of the plated material, g/cm^3 (see page 5 Table of Density Values for the D =)
A = surface area in square centimeters.

Since the plated surface area on a Test Strip is 7.74 square centimeters, the formula for thickness can be shortened as follows:

$$T = 0.0509\ (W \div D)$$

To determine the thickness of a nickel deposit that weighed .0349 grams, the calculation would become:

$$T = \frac{.0349}{8.88} \times .0509 = .000200 \text{ inch}$$

Note: If using x-ray for thickness it would = T

After the deposit thickness is known and the number of increments spread between the Test Strip leg tips has been determined, the deposit stress can be calculated thus:

$$S = UKM \div 3T$$

See Table 1 on page 8 for M values

S = pounds per square inch
U = number of increments spread
T = deposit thickness in inches
K = strip calibration constant
M = modulus of elasticity of the deposit divided by the modulus of elasticity of the substrate material.

The value for K, a calibration factor, is supplied with each lot of Test Strips.

Use this link for viewing the Deposit Stress Analyzer Video:

https://m.youtube.com/watch?v=3HFPiCnlfN0

PN: 1194 - COPPER–IRON ALLOY

Solve the equation **S = UKM ÷ 3T** as follows:

U = Total increments spread of the Test Strip leg tips on both sides of the zero line.

T = Deposit thickness in inches.

K = The calibration constant value provided by the manufacture.

M = 1.7143 (Nickel plating). The correction factor for the difference in the modulus of elasticity between the deposit and that of the substrate = EDeposit ÷ ESubstrate = 30,000,500 ÷ 17,500,000 = 1.7143. See Table 1 on page 8 for other materials.

S = The internal deposit stress in pounds per square inch.

PN: 270 - PURE NICKEL 0.0011 INCH THICK

Solve the equation **S = UKM ÷ 3T** as follows:

U = Total increments spread of the Test Strip leg tips on both sides of the zero line.

T = Deposit thickness in inches.

K = The calibration constant value provided by the manufacture.

M = 1.000 (Nickel Plating). The correction factor for the difference in the modulus of elasticity between the deposit and that of the substrate= EDeposit ÷ ESubstrate = 30,000,500 ÷ 30,000,500 = 1.000. See Table 1 on page 8 for other materials.

S = The internal deposit stress in pounds per square inch.

DEPOSIT STRESS EQUATION EXAMPLES

RECOMMENDED PLATING CONDITIONS FOR NICKEL PLATING:

Temperature	130	°F
Current Density	30	Amps/square foot
Plating Current	0.25	Amps
Plating Time:	2-4	Minutes 12 seconds
(95% cathode efficiency)		
Deposit Thickness Target	50-100	microinches

For critical certifiable work, average the results of several plated Test Strips.

Note: *If the above test conditions cause the Test Strip leg tips to spread beyond 20 units, reduce the deposition time and the deposit thickness for the test to improve accuracy.*

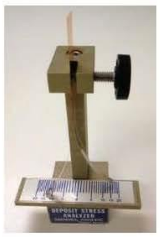
Note: To convert to metric: 1 PSI x .07031 = kg/cm2

TABLE OF DENSITY VALUES (GRAMS/CUBIC CENTIMETER)

Deposited Metal	Density
Cadmium	8.64
Chromium	7.19
Cobalt	8.80
Copper	8.93
Gold (Soft)	19.30
Gold (Hard)	19.32
Nickel	8.88
Palladium	12.02
Platinum	21.45
Rhodium	12.45
Silver	10.50
Tin	7.26
Zinc	7.10

DEPOSIT STRESS

For more information visit: ***https://specialtytest.com***



Deposit Stress Analyzer

PN: 683 - Deposit Stress Analyzer

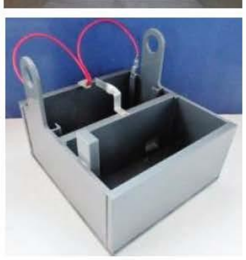
The Deposit Stress Analyzer Measurement Stand (DSA Stand) supports the plated Test Strip over an increment scale so the total number of units spread between the tips of the plated Test Strip can be read. The increment reading is then included in a formula to calculate the internal deposit stress in pounds per square inch.

Plating Cell 785 Series

PN: 785A* - Acrylic Construction with flow holes

PN: 785C* - Acrylic construction no flow holes

These cells are designed for precision deposit stress measurements. They offer a standard geometry with respect to anode size and positioning. The Acrylic Construction Plating Cell with flow holes (PN: 785A) are designed for in-tank use. This cell has openings at each end on the bottom sides to allow solution to flow into the cell when the cell is lowered into the plating bath. For a lab setting use the following: Acrylic Construction Plating Cell (PN: 785C). This cell has no openings on the bottom sides and is a self-contained unit. If it is desired to use a single plating cell for both in-tank and lab settings, the Acrylic Construction Plating Cell with flow holes (PN: 785A) fits inside the Container (PN: 100) for lab work. All plating cells contain a pocket at each end to hold a 2⅜" x 2⅜" x ⅛" anode in place and a bracket to hold a Test Strip in the plating bath. PN: 785 Series max temperature is 212 degrees F, and holds approximately 1750 ml of solution.



Plating Cell 800 Series

PN: 800L* - Acrylic Construction, includes PN: 404 Pump.

PN: 800PVC - PVC Construction

The 800 Series Plating Cells are a self contained unit. The plating solution is poured into the cell for use in a laboratory. A dividing wall separates the cells into two equal sections. One section is utilized to heat using the Immersion Heater (PN: 3046) and agitate the solution selected for the evaluation of deposit stress using the Submersible Pump (PN: 404). The dividing wall has an opening at each end to permit solution flow through both cell sections. All plating cells contain a pocket at each end to hold a 2⅜" x 2⅜" x ⅛" anode in place and a bracket to hold a Test Strip in the plating bath. Size 8½" x 9¼" x 4¼" (not including handles). PN: 800PVC max temperature is 360 degrees F. PN: 800L max temperature is 212 degrees F. Each cell holds approximately 3500 ml of solution.

***The PN: 785 Series and 800L Should not to be used with Chromic acid, or placed on a hot plate.**

ANALYZER PRODUCTS

In-Site Plating Cell

PN: 492

The In-Site Plating Cell is small enough to be permanently mounted in tank to allow direct stress monitoring during the plating cycle. No additional anodes are required. In-Site Plating Cell gives accurate and consistent stress readings; simply use the same current density at which the parts are being plated. However, the test cannot be run while parts are being plated, unless using a separate rectifier for this purpose. Simply insert a cleaned Test Strip into the cell through its wider top opening. Clamp the strip to the center rib in the opening with the negative output clip. The Test Strip leg tips must be inside the cell, equally exposed to the open ports. Dimensions: Adjust to 7” (172 mm) to 11” (275 mm) x 7/8” (21 mm) diameter. In-Site Plating Cell PN: 492 max temperature is 180 degrees F.

Immersion Heater

PN: 3046, 120 Voltage

The Immersion Heater is for use in the 800 Series Plating Cells (PN: 800L & PN: 800PVC). The Immersion Heater is 500 watts and the heated area is a horizontal 3⅛ inch diameter loop. The heater attaches to the heater holder of the 800 Series Plating Cell to keep the heated loop away from the cell sides and bottom. The Heater Dial Temperature Controller has a sensitivity of ± 2°F when the solution is agitated. A top-mounted pilot light indicates that heater is on. The Immersion Heater features a plastic grip handle and a 6-foot, three-wire cord, with U.S. standard plug.

Submersible Pump

PN: 404, 120 Voltage

The Submersible Pump is included with purchase of the 800 Series Polycarbonate Construction Plating Cell (PN: 800L). This pump does not withstand temperatures above 180°F. Not for use with chromic acid. Minimal setting recommended.

Container

PN: 100

This Polypropylene container is used to hold the Plating Cell 785 Series and is used for Test Strip plating on a laboratory bench. It will hold one gallon of plating solution.

Direct Current Power Supply 0-2 Amp

PN: 15020-2 (product may differ from photo)

The Direct Current Power Supply is recommended due to the low test amperage (0-2 amps) required for plating a Test Strip and the accuracy of the ampere meters used for these power supplies. Most Test Strip applications us a current of 0.25 amps.

Technical parameters:
Input Voltage: 104~127V AC(60Hz)
Voltage indication accuracy: LED/LCD± 1%+2 digits, analogue display 2.5%

TABLE 1 **Values for M in Standard English Measurement**

Test Strip Material		1194	270
E Substrate		17,500,000	30,000,500
Stock Thickness, inches		0.002	0.0011
Plating Metal	**E Deposit Value**	**M Value**	**M Value**
Cadmium	8,010,000	0.4577	0.2669
Chromium	36,000,000	2.0571	1.1999
Cobalt	30,600,000	1.7485	1.0199
Copper	16,000,000	0.9142	0.5333
Cold (Soft)	11,200,000	0.6400	0.3733
Nickel	30,000,000	1.7143	1.0000
Palladium	17,000,000	0.9714	0.5667
Platinum	24,800,000	1.4171	0.8266
Rhodium	52,100,000	2.9771	1.7366
Silver	11,000,000	0.647	0.3666
Tin	5,900,000	0.337	0.1966
Zinc	14,000,000	0.8228	0.4666

E Substrate = modulus of elasticity of the substrate material (Test Strip material).

E Deposit = modulus of elasticity of the plating deposit.

M = modulus of elasticity of the E Deposit ÷ modulus of elasticity of the E Substrate (in PSI)

For electoless nickel alloy see our web site under Deposit Stress Analyzer System

Note: The highest value of Internal Deposit Stress as obtained on a Stress-versus-plating-thickness curve is usually the truest value of the internal deposit stress.

TABLE 2 **Approximate Depositing Rates for Metals**

Electrolyte	% Efficiency	Amps	ASF*	µ"/Minute	Deposit, µ" **
Cadmium	95	0.168	20	26.1	200
Chromium Semi-Br.	12	2.94	350	10.53	20
Copper (cyanide)	90	0.168	20	34.7	100
Copper (acidic)	100	0.33	40	37	100
Gold (soft)	100	0.25	30	26	100
Gold (hardened)	70	0.25	30	44.5	100
Nickel	95	0.33	40	31.7	100
Palladium	90	0.25	30	35.5	100
Platinum	90	0.042	5	0.83	100
Rhodium	60	0.084	10	4.37	20
Silver	100	0.13	15	59.4	100
Tin(alkaline)	75	0.25	30	107.8	200
Tin (acidic)	99	0.17	20	22.4	200
Zinc (acidic)	100	0.25	30	30.8	200
Zinc (cyanide)	90	0.25	30	30.2	200

*** Convert amps per square foot to amps per square decimeter by diving the numbers shown about by 9.29.**

**** Average deposit thickness recommended on Test Strips.**

Note: Target Deposit Thickness is 100 Microinches.

For more information visit **https://specialtytest.com**