

Tribology: **A/SP Procedures For Testing Characteristics of Automotive Sheet Steel Lubricants**

1.0 Introduction

1.1 Scope

This specification was developed by engineers from the automobile and steel industries. The purpose of this document is to specify the acceptable performance requirements for an automotive sheet metal lubricant. Lubricants include mill oils, prelubes, draw compounds, blankwashes, and dry films. The term "lubricant" used in these procedures is used to describe any product added to the sheet metal that serve the primary purposes of rust prevention, friction reduction, or sheet steel cleanliness (see Section 1.3 - Lubricant Definitions).

The participating automotive companies require that automotive sheet steel lubricants be evaluated using the following procedures:

- [Drawbead Simulator \(DBS\) Testing](#)
- [Corrosion and Stain Resistance Testing](#)
- [Welding Compatibility Testing](#)
- [Cleanability and Phosphate Testing](#)
- [Electrocoat Compatibility Testing](#)
- [Adhesive and Sealer Compatibility Testing](#)

Successfully passing these laboratory tests indicates that a lubricant has acceptable performance in these categories. These results form a basis for acceptance by the automotive and steel industry. This procedure does not replace the individual companies lubricant approval procedure. Companies may require additional testing along with plant trials before final approval is granted. Contact the individual companies for their procedures.

1.2 Discussion

Lubricants serve three primary functions in automotive stampings. They (1) reduce friction in the forming process to improve formability of metals and reduce die wear, (2) clean blanks to reduce dirt and prevent high spots on exposed surface panels, and (3) protect the sheet metal and stamped parts from corrosion until the part is painted. The first two performance tests in this procedure, Lubricity and Corrosion, address two of the three primary functions. A performance test to characterize the cleanliness of blanks has not been developed to date.

Since lubricants must remain on the stamped parts to provide corrosion protection, they can affect product performance such as weldability, paintability, and functional performance of adhesives and sealers. To insure compatibility, four engineering tests are performed; Weldability, Cleanability and Phosphate Compatibility, Electrocoat Primer Compatibility, and Adhesive and Sealer Compatibility.

All six (6) performance tests outlined in this procedure are simulation tests. Actual field performance is determined separately during functional trials at the individual automotive companies. Functional trials are expensive and time consuming, and passing these simulative tests provide a high confidence level that the lubricant will perform to design intent and pass subsequent functional trials.

1.3 Lubricant Definitions

Mill Oil - a mill applied oil primarily used for the preservation of sheet metal.

Prelube - a mill-applied oil primarily used for the preservation of sheet metal that is formulated to enhance formability.

Drawing Compound - a press-applied lubricant formulated to enhance formability and protect formed metal parts during interim inventory.

Blankwash Compound - a water/oil dilutable compound formulated to clean the blank and enhance formability. It is normally applied via roll coater prior to introduction of the blank into the press.

Dryfilm Lubricant - a solid film lubricant applied to the metal formulated to enhance formability.

Prephosphated - a phosphate surface treatment used together with wet lubricants to enhance formability and corrosion protection

2.1 Scope

This industry preferred test method determines the Coefficient of Friction (COF, μ) for forming lubricants on sheet metal under drawbead conditions. The DBS friction value obtained with this test procedure only represents one test condition; sheet metal pulled through draw beads. The same material, lubricant, and die combination could result in a different friction value under other conditions.

To improve the usefulness of the data and isolate the effect of the lubricant, the forming lubricant shall be tested with and compared to a control lubricant. This comparison with the control lubricant under the same test conditions will allow the user to evaluate the data with minimal concern for laboratory bias due to differences in test equipment and procedures. Usually, the control lubricant will be the predominate lubricant in use and the automotive stamping plants. Contact the customer to determine the control lubricant prior to testing.

2.2 Reference Documents

2.2.1 Nine, H. D., "Drawbead Forces in Sheet Metal Forming, " Mechanics of Sheet Metal Forming: Behavior and Deformation Analysis, Koistinen, D.P and Wang N. M. -ed., Plenum Press, New York, NY, 1978, pp. 179-211.

2.2.2 Nine, H.D., "Testing Lubricants for Sheet Metal Forming," Novel Techniques in Metal Deformation Testing, Wagoner, R.H. -ed., The Metallurgical Society of AIME, Warrendale, PA, 1983, pp. 31-46.

2.2.3 Schey, J.A. and Smith, M.K., "Report of NADDRG Friction Committee on Reproducibility of Friction Tests Within and Between Laboratories," S'E Paper No. 930811, 1993.

2.3 General Equipment

2.3.1 Drawbead simulator apparatus

2.3.1.1 Minimum 150 axial stroke actuator

2.3.1.2 Minimum 25 mm clamp stroke actuator

2.3.1.3 Axial tension load cell

2.3.1.4 Clamping compression load cell

2.3.1.5 Roller bead fixtures

2.3.1.6 Fixed bead fixture

2.3.1.7 Sample gripping device

2.3.2 Transducer data recording device (i.e. xy recorder or computer)

2.4 Test Materials

2.4.1 Contact customer to determine test panel material. All tests shall be conducted using the same lot of material since sheet thickness and strength affects DBS results. For a complete friction analysis, testing should be performed on the following m

Cold Rolled Steel (uncoated)
Hot Dipped Galvanized
Electro Galvanized
Hot Dipped Zinc Iron
Electro Zinc Iron

2.4.2 Two (2) tests shall be performed; one with the test lubricant and one with the control lubricant. Contact customer to determine control lubricants prior to testing.

2.5 Test Preparation

2.5.1 Panel preparation. Panel preparation steps to be used for control and sheet metal forming lubricant panels follows.

2.5.1.1 Cutting samples for sheet steel. Special precautions must be taken to minimize materials thickness variation. Two methods are accepted.

Longitudinal Cutting Method

Long side of sample shall be cut parallel to material's rolling direction

Obtain a minimum size sheet, 1400 mm long (parallel to rolling direction) and 300 mm wide. Sheet material must be at least 100 mm from the coil edge to minimize effects of gauge crown.

Cut twenty-four (24) samples as shown in Figure 1. Individual sample sizes should be 50 mm (25 mm for some DBS machines) x 350 mm; ten (10) for fixed bead testing [five (5) for control lubricant and five (5) for test lubricant], ten (10) for roller bead testing, and four (4) for fixed bead conditioning [two (2) for control lubricant]. Identify samples with the identification codes on the same side of the metal surface. Deburr all samples.

Figure 1.
Rolling Direction
←→

1A	1B	1C	1D
2A	2B	2C	2D
3A	3B	3C	3D
4A	4B	4C	4D
5A	5B	5C	5D
CS	CS	CS	CS

Samples A and D are tested with the roller beads.

Samples B are tested with fixed beads using the control lubricant.

Samples C are tested with fixed beads using the test lubricant.

Samples CS are condition strips for fixed bead preparation (Section 2.5.2.5)

Transverse Cutting Method

Long edge of sample should be cut transverse to material's rolling direction.

Obtain a minimum size sheet, 950 mm long (parallel to rolling direction) and 350 mm wide. Sheet material must

be at least 100 mm from coil edge to minimize effects of gauge crown.

Cut nineteen (19) samples as shown in Figure 2. Individual sample sizes should be 50 mm (25 mm for some DBS machines) x 350 mm; ten (10) for fixed bead testing, [five (5) for control lubricant and five (5) for test lubricant], five (5) for roller bead testing, and four (4) for fixed bead conditioning [two (2) for control lubricant and two (2) for test lubricant]. Identify samples with the identification codes on the same side of the metal surface. Deburr all samples.

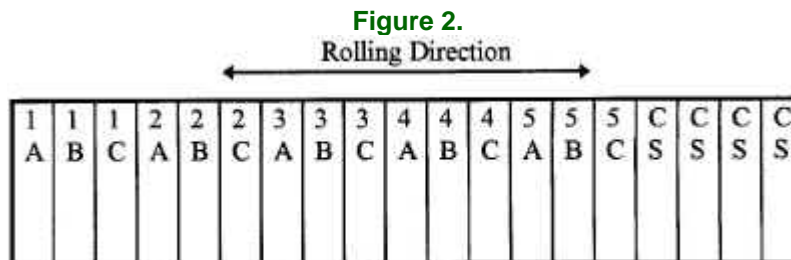


Figure 2

Samples A are tested with the roller beads.

Samples B are tested with fixed beads using the control lubricant

Samples C are tested with fixed beads using the test lubricant.

Samples CS are condition strips for fixed bead preparation (Section 2.5.2.5)

2.5.1.2 Sheet samples to be tested with the roller beads shall be cleaned with toluene using a clean lint-free cloth followed by a toluene rinse. Do not apply any lubricants to these samples.

2.5.1.3 Sheet samples to be tested with the fixed beads including fixed bead condition strips shall be prepared in the following manner:

Mill Oil - Follow steps 1,2,4

Pre-lube - Follow steps 1,3,4

Blankwash - Follow steps 1,2,4,5

Press Applied Drawing Compound - Follow steps 1,2,4,5

Dry Film - Test as received

Prephosphate - Follow steps 1,2,4 using control mill oil

Step 1 Clean test panels (both sides) with toluene using a clean lint-free cloth, followed by a toluene rinse. Allow solvent to completely evaporate before proceeding to next step.

Step 2 Apply mill oil using #0 draw bar on both sides.

Step 3 Apply prelube using #0 draw bar on both sides.

Step 4 Place panels in a horizontal position. Age for 24 hours at room temperature.

Step 5 Apply blankwash on both sides in excess immediately prior to testing.

2.5.2 Fixed Bead Preparation

2.5.2.1 Clean the fixed beads with 600 grit emery cloth in the axial direction. If all scratches, etc. are not removed, begin with coarser paper and progress to finer paper until finishing with 600 grit emery cloth. Clean the fixed beads with a clean, c

2.5.2.2 Adjust both the fixed bead and the roller bead clearance (each gap) to metal thickness plus 10% of metal thickness.

2.5.2.3 Adjust the roller guide clearance (on the bead fixture) to metal thickness plus 20% of metal thickness.

2.5.2.4 Coat the fixed beads with a liberal application of the lubricant under test.

2.5.2.5 Run two (2) conditioning strips as prepared in Section 2.5.1.3 with the lubricant under test.

2.5.2.6 Fixed bead preparation must be performed before each set of tests; or, when the lubricant or the material is changed.

2.5.3 Roller Bead Preparation

2.5.3.1 Remove all scratches and clean the roller as described in 2.5.2.1.

2.5.3.2 Adjust the bead and roller guide clearances as described in 2.5.2.2 and 2.5.2.3

2.5.3.3 Place the specimen through the bead set, center the specimen through the bead set, center the specimen relative to the beads, and clamp with the grips. The stamped side will face the male bead for all metal surfaces to be measured.

2.5.3.4 Roller bead preparation must be performed before each set of pulls or when the material is changed.

2.6 Test Procedure

2.6.1 Draw Bead Simulator Operation

2.6.1.1 Insert the desired bead set into the test fixture

2.6.1.2 Zero the pull load and normal load cells.

2.6.1.3 Insert the specimen (the coded side towards the male bead and coded end in the clamping device).

2.6.1.4 Close the bead set until the interleaf distance is reached. This value is equal to the bead diameter (usually 9.5 mm) plus the metal thickness.

2.6.1.5 Pull the strip through the draw bead simulator. Normal speed is 50 to 100 mm/s.

2.6.1.6 Repeat for the remaining samples

2.6.1.7 Perform fixed bead preparation any time a different lubricant or material is tested.

2.6.1.8 Perform roller bead preparation any time a different material is tested

2.7 Evaluation and Results

2.7.1 Calculating the coefficient of friction (COF)

2.7.1.1 Obtain the pull load and normal load for each specimen. The load shall be calculated between 5 m and 100 mm. of the pull.

2.7.1.2 Calculating method will depend upon which cutting method is used in Section 2.5.1.1.

Longitudinal Cutting Method

Calculate the individual COF using the equation in Section 2.7.1.3 for the control and test lubricant using the four A-D coupons on each of the five tests (1-5). Average the pull forces from the A & D coupons to obtain the roller force for each test. Average the five individual COF values for the control and the five individual COF values for the test lubricant to obtain one COF for the test lubricant and one COF for the control lubricant.

Transverse Cutting Method

Calculate the individual COF using equations in Section 2.7.1.3 for the control and test lubricant using the three A-C coupons on each or the five tests (1-5). Average the five individual COF values for the control and the five individual COF values for the test lubricant to obtain one COF for the test lubricant and one COF for the control lubricant.

2.7.1.3 Calculate the Coefficient of Friction as follows:

$$\mu = \frac{P_f - P_r}{\pi \times N_f}$$

P_f is the pulling force obtained with the fixed beads

P_r is the pulling force obtained with the roller beads

N_f is the normal force obtained with the fixed beads

2.8 Reporting

2.8.1 The following general information should be reported:

2.8.1.1 Description of drawbead simulator used (picture preferred).

2.8.1.2 Fixed and roller bead material

2.8.1.3 Sheetmaterial type, coating, gage, source, and mechanical properties

2.8.1.4 Cutting Method (i.e. Longitudinal or Transverse)

2.8.1.5 Sample size

2.8.2 The following information should be reported for each test

2.8.2.1 Gauge of each sample

2.8.2.2 Normal load, pull loads, COF for each test lubricant and control lubricant using chart from Section 2.8.4.

2.8.2.3 Force/Pull-length plots for each pull

2.8.3 Report any known deviations from this procedure.

2.8.3.1 Oil Application: There is some debate over the importance of oil application which will require future studies to understand its effects. Many laboratories currently use paint brushes. Report specific oil application procedure if it deviates fr

2.8.3.2 Bead Preparation: Report deviation or any additional procedures used when preparing the fixed or roller beads.

2.8.4 Bead Preparation: Report deviation or any additional procedures used when preparing the fixed or roller beads.

P_f - Fixed Bead Pull force
N_f -Fixed Bead Normal force

Pr - Roller Bead Pull force
Nr - Roller Bead Normal force
COF (μ) - Calculated coefficient of friction

Test	P _r	N _r	P _r	N _r	COF (μ)
1					
2					
3					
4					
5					
Avg.					

2.9 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not intend to address all the safety problems associated with its use. It is the responsibility of the user of this method to establish appropriate safety and health practices and determine the applicability or regulatory limitations prior to use.

3.1 Scope

This test procedure describes four (4) methods to evaluate the ability of lubricants to prevent corrosion and staining on sheet metal. These methods are applicable for forming lubricants; including mill oils, draw compounds, blank washes, prelubes, and dry films.

3.1.1 TEST METHOD A - Acid Atmosphere. Expose samples to 16 hours of 25 PPM hydrochloric acid.

3.1.2 TEST METHOD B - Condensing Humidity. Expose samples to 10 cycles consisting of 16 hours, 38 degrees C, 100% RH; 8 hours room temperature.

3.1.3 TEST METHOD C - Bake Stain. Expose one (1) set of panels for seven (7) days, 50 degrees C in the horizontal position and expose one (1) set of panels seven (7) days, 50 degrees C, 85% RH in the horizontal position.

3.1.4 TEST METHOD D - Sandwich Test. Expose samples vertically at 50 degrees C, 85% RH, Open one (1) sandwich at 1,2,6, and 12 week intervals.

3.2 Reference Standards

ASTM D10-95, ASTM D414-93, and D2247-94

3.3 General Equipment and Test Materials

3.3.1 Test Chambers. See respective test procedures for equipment required

3.3.2 #0 draw bar and #8 draw bar

3.3.3 Rack capable of holding test panels 15 degrees from vertical with 50 mm space between panels.

3.3.4 Toluene

3.3.5 Analytical balance

3.3.6 Clean lint-free cloth

3.3.7 Sponge

3.3.8 2 liter beaker or equivalent

3.3.9 Current production phosphate cleaner

3.3.10 Isopropyl alcohol (IPA)

3.3.11 Test Panels: a set consists of one (1) panel of each of the following five (5) substrates.

Cold Rolled Steel

Hot Dipped Zinc Iron - A45

Electro Zinc Iron - A45

Electro Galvanized - 60G

Hot Dipped Galvanized - 60G min. spangle

3.3.12 Control Lubricants: Contact customer to determine controls prior to initiating testing.

3.4 Panel Preparation

3.4.1 To prepare a mill oil for evaluation follow steps 1, 2, and 6.

3.4.2 To prepare a prelube for evaluation follow steps 1, 3, and 6.

3.4.3 To prepare a draw compound & blankwash for evaluation follow steps 1, 2, 4, 5, and 6.

3.4.4 To prepare a dry film lubricant for evaluation proceed directly to the appropriate test method (no preparation is required).

Step 1 Clean test panels (both sides) using a toluene wipe with the clean lint-free cloth, followed by a Toulon rinse.

Step 2 Apply mil oil using #0 draw bar on one side

Step 3 Apply prelube using #0 draw bar on one side

Step 4 Place panels in a rack 15 degrees from the vertical position. Age for 24 hours at room temperature.

Step 5 Coat panel with draw compound (at recommended dilution) using draw bar #8 over control mil oil. Age horizontally for 45 minutes at room temperature.

Step 6 Place panels in a rack 15 degrees from the vertical position. Allow to age 72 hours at room temperature prior to corrosion test exposure.

Note: Space all panels 50 mm apart on racks. The front panel on each rack should be a protective blank.

3.4.5 Confirm lubricant coating weight by the following:

3.4.5.1 After lubricant application, weigh the 100 x 150 mm panel to the nearest 0.1 mg on an analytical balance.

3.4.5.2 Degrease coupon using appropriate technique per Step 1 of Section 3.4.4.

3.4.5.3 Re-weigh the panel to the nearest 0.1 mg.

3.4.5.4 Calculate lubricant coating in g/m².

Coating Weight =

$$\frac{\text{Weight loss}}{\text{Total Surface Area}}$$

3.5 Report

- 3.5.1 Identification and concentration of the test and control lubricants.
- 3.5.2 Sample preparation and conditioning of test panels.
- 3.5.3 Test conditions: temperature, humidity, and duration, etc. As applicable to the specific test method.
- 3.5.4 Lubricant coating weight for each lubricant/substrate combination, reference Section 3.4.5.
- 3.5.5 Test results, for test and control lubricants, with any additional observations.

3.6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not intend to address all the safety problems associated with its use. It is the responsibility of the user of this method to establish appropriate safety and health practices and determine the applicability or regulatory limitations prior to use.

3.7 Test Method A - Acid Atmosphere

3.7.1 Equipment and Test Materials

- 3.7.1.1 Six (6) sets of 75 x 125 mm test panels, reference Section 3.3.11
- 3.7.1.2 Exposure Panels. Four (4) sets of panels [two (2) test lubricants, two (2) control lubricants].
- 3.7.1.3 Coating Weight Panels. Two (2) sets of panels [One (1) test lubricant, one (1) control lubricant].
- 3.7.1.4 Control Lubricants. Select control lubricant based on product to be evaluated, reference Section 3.3.12.
- 3.7.1.5 Large round jar or desiccator, typically either (a) jar, cylindrical, plain, 300 mm O.D 300 mm in height, or (b) Desiccator, body only, 250 mm size.
- 3.7.1.6 Plexiglas cover 6 mm thick to fit on desiccator.
- 3.7.1.7 Small Gearmotor, Model CA, 150 to 400 rpm, or equivalent. Available from:
Hurst Manufacturing Corporation
P.O. Box 326, Princeton, IN 47670
- 3.7.1.7 NOTE: Gearmotor should be reversible. During operation of test, more uniform results are obtained if the stirring rotor direction is changed about every five (5) minutes. This can be done automatically with an external timer/single pole-double t
- 3.7.1.8 Plexiglas (4.5 mm or less) sheet and 50 mm of 18mm diameter Plexiglas rod for rotor.
- 3.7.1.9 Wide mouth dish for HCl, 80mm x 40 mm crystallization dish or equivalent.
- 3.7.1.10 Eyedropper.
- 3.7.1.11 Hydrochloric Acid. Reagent grade.
- 3.7.1.12 Distilled or deionized water less than 10 PPM maximum dissolved solids.
- 3.7.1.13 Acetone.

3.7.2 Test Preparation

3.7.2.1 Preparation of HCl Solution. To make up a 25 PPM HCl solution, mix reagent grade concentrated HCl acid (36.5-38%), with distilled or deionized water in the proportions below:

Concentration in test chamber: 25 PPM

Concentrated Acid: 100 ml

Deionized Water: 191 m

3.7.2.2 Test Chamber

- A. Add 200 ml of distilled and/or deionized water directly to the bottom of the chamber.
- B. Add 50 ml of HCl solution to the beaker and centrally place beaker on the bottom.
- C. Replace lid and turn on motor/rotor at least 15 minutes before test panels are inserted in chamber. (The sample slots should be covered during the equilibration of the test chamber).
- D. The acid solution and water in the bottom of the chamber should be changed weekly.

3.7.2.3 Prepare test and control materials, reference Section 3.4.

3.7.3 Test Procedure

Expose the sample for 16 hours uninterrupted.

3.7.4 Evaluation

3.7.4.1 Evaluate lubricant coating weight for each lubricant/substrate combination, reference Section 3.4.5.

3.7.4.2 Post Cleaning. After testing, clean panels by lightly rubbing with a sponge dipped in current production phosphate cleaner at recommended concentration. Rinse with tap water, deionized water, and isopropyl alcohol (IPA).

3.7.4.3 Evaluate degree of corrosion (red or white) using both unaided eye and 600x magnification.

NONE=	No change
SLIGHT=	Barely observable with normal examination
MODERATE=	Modest change, readily noticeable
SEVERE=	Very obvious change

3.7.4.4 Acceptance criteria (pass/fail) is based on the performance of the test lubricant as compared to the control lubricant.

3.8 Test Method B - Condensing Humidity

3.8.1 Testing Equipment and Materials

3.8.1.1 Eight (8) sets of 100 x 150 mm test panels, reference Section 3.3.11.

3.8.1.2 Exposure Panels. Six (6) sets of panels [three (3) test lubricant, three (3) control lubricant].

3.8.1.3 Coating Weight Panels. Two (2) sets of panels [one (1) test lubricant, one (1) control lubricant].

3.8.1.4 Select control lubricant based on product to be evaluated, reference Section 3.3.12

3.8.1.5 Humidity Cabinet. Capable of maintaining 38 degrees C, 100% RH. Reference ASTM D224.

3.8.2 Test Preparation

Prepare test and control materials, reference Section 3.4.

3.8.3 Test Procedure

Place samples in a rack 15 degrees from vertical. Expose samples to 10 cycles consisting of 16 hours, 38 degrees C, 100 RH; 8 hours room temperature.

3.8.4 Evaluation

3.8.4.1 Evaluate lubricant coating weight for each lubricant/substrate combination, reference Section 3.4.5.

3.8.4.2 Evaluate after each cycle for occurrence of pinpoint corrosion spots. Count and record the number of spots.

3.8.4.3 At the conclusion of 10 cycles, lightly rub panels with a sponge dipped in current production phosphate cleaner at recommended concentration. Rinse with tap water, deionized water and isopropyl alcohol. Evaluate as per Section 3.8.4.2.

3.8.4.4 Acceptance criteria (pass/fail) is based on the performance of the test lubricant as compared to the control lubricant.

3.9 Test Method C - Bake Stain

3.9.1 Equipment and Test Materials

3.9.1.1 Six (6) sets of 100 x 150 mm test panels, reference Section 3.3.11

3.9.1.2 Exposure Panels. Four (4) sets of panels [two (2) test lubricants, two (2) control lubricant].

3.9.1.3 Coating Weight Panels. Two (2) sets of panels [one (1) test lubricant, one (1) control lubricant].

3.9.1.4 Control Lubricants: Select control lubricant based on product to be evaluated, reference Section 3.3.12

3.9.1.5 Air Circulating Humidity Cabinet. Capable of maintaining 50 degrees C, 85RH.

3.9.1.6 Air Circulating Oven, Capable of maintaining 50 degrees C.

3.9.1.7 Eye dropper.

3.9.2 Test Preparation

Prepare test and control lubricants as follows:

3.9.2.1 For mill oil or prelube evaluation dip lower one-half of panel in mill oil or draw compound. Place sample horizontal and using an eyedropper apply a 25 to 50 mm diameter puddle overlapping the dipped and bare area of the panel.

3.9.2.2 For draw compound evaluation:

3.9.2.2.1 Procedure A - Coat lower one-half of panel with control mill oil, reference Section 3.4.4, Steps 1, 2, and 4. Dip lower one-half of panel in draw compound. Place sample horizontal and using an eyedropper apply a

25 to 50 mm diameter puddle overlapping the dipped and bare area of the panel.

3.9.2.2.2 Procedure B - Dip lower one-half of panel in draw compound. Place sample horizontal and using an eyedropper apply a 25 to 50 mm diameter puddle overlapping the dipped and bare area of the panel.

3.9.2.2.3 NOTE: Confirm appropriate test preparation procedure prior to initiating tests with the requesting materials engineer.

3.9.3 Test Procedures

3.9.3.1 Oven: Place one set of test panels in oven and bake for seven (7) days at 50 degrees C in horizontal position.

3.9.3.2 Humidity Chamber: Place the other set of panels in humidity chamber at 50 degrees C, 85% RH for seven (7) days in horizontal position.

3.9.4 Evaluation

3.9.4.1 Evaluate lubricant coating weight, reference Section 3.4.5. Report coating weight for each lubricant/substrate combination.

3.9.4.2 Post Cleaning. After testing, clean panels by lightly rubbing with a sponge dipped in current production phosphate cleaner at recommended concentration. Rinse with tap water, deionized water and IPA.

3.9.4.3 Evaluate stain severity and appearance.

1. No change
2. Lighter or darker than background
3. Uniform
4. Peripheral ring (around puddled area)
5. Spots
6. Blotchy

3.9.4.4 Acceptance criteria (pass/fail) is based on the performance of the test lubricant as compared to the control lubricant.

3.10 Test Method D - Sandwich Test

3.10.0.1 Mill applied lubricants require testing for 12 weeks. These include mill oils, prelubes, prephosphates, and dry films.

3.10.0.2 Press applied lubricants require testing for 6 weeks. These include drawing compounds and blankwashes.

3.10.1 Equipment and Test Materials

3.10.1.1 Press applied lubricants require testing for 6 weeks. These include drawing compounds and blankwashes.

Mill applied lubricants - Eighteen (18) sets
 Sixteen (16) sets for exposure
 Eight (8) for test lubricant
 Eight (8) for control lubricant
 Two (2) sets for coating weight measurement
 One (1) for test lubricant
 One (1) for control lubricant

Press applied Lubricants - Fourteen (14) sets
Twelve (12) sets for exposure
Six (6) for test lubricant
Six (6) for control lubricant
Two (2) sets for coating weight measurement
One (1) for test lubricant
One (1) for control lubricant

3.10.1.4 Control Lubricants. Select control lubricant based on product to be evaluated, reference Section 3.3.12.

3.10.1.5 Air Circulating Humidity Cabinet. Capable of maintaining 50 degrees C, 85%RH

3.10.1.6 Paper clips.

3.10.2 Test Preparation

3.10.2.1 Prepare test and control materials, reference Section 3.4.

3.10.2.2 Sandwich two (2) panels each (3 assemblies for mill applied lubricants and 4 assemblies for press applied lubricants) with coated sides together, fastening with four (4) paper clips to ensure contact along the entire panel surface.

3.10.3 Place samples in a rack 15 degrees from vertical. Expose to 50 degrees C, 85% RH.

3.10.3.1 Open one sandwich per test combination at the expiration of 1, 2, 6, and 12 weeks for mill applied lubricants and at the expiration of 1, 2, 6 weeks for press applied lubricants.

3.10.3.2 Post Cleaning. After testing, clean panels by rubbing lightly with a sponge dipped in current production phosphate cleaner at recommended concentration. Rinse with tap water, deionized water and IPA.

3.10.3.3 Evaluation

3.10.4 Test Procedure

3.10.4.1 Evaluate lubricant coating weight, reference Section 3.4.5. Report coating weight for each lubricant/substrate combination.

3.10.4.2 Evaluate percent of rust per ASTM D610. Rate obvious white or red rust seen by the naked eye based on the following scale:

<u>RUST Grades</u>	<u>DESCRIPTION</u>	<u>ASTM-SSPC Photo Standards</u>
10	no rusting or less than 0.01% of surface rusted	unnecessary
9	minute rusting, less than 0.03% of surface rusted	No.9
8	few isolated rust spots < 0.1% of surface rusted	No. 8
7	few isolated rust spots <0.3% of surface rusted	None
6	extensive rust spots but <1% of surface rusted	No. 6
5	rusting to the extent of 3% of surface rusted	none
4	rusting to the extent of 10% of surface rusted	No. 4
3	approximately one sixth of the surface rusted	none
2	approximately one third of the surface rusted	none
1	approximately one half of the surface rusted	none
0	approximately 100% of the surface rusted	unnecessary

3.10.4.3 Acceptance criteria: (pass/fail) is based on the performance of the test lubricant as compared to the control lubricant.

4.1 Scope

This procedure describes a resistance spot welding Current Break-Through Screening Test designed to determine the effect that a lubricant ("fresh" and "aged") has on the initiation of weld current flow during welding. If the lubricant increases the contact resistance of the sheet surface significantly, difficulties in initiating current flow can be encountered. This could lead to inadequate nugget development or no weld at all, depending on how much of the weld time is required to break through the resistive coating. Such a condition is not acceptable for production conditions because it can lead to discrepant or no welds.

These lubricants would include mill oils, pre-lubes, drawing compounds, blankwash lubricants, tapping fluids, dry film lubricants, prephosphate and others specified by the customer.

This weldability test is a screening test only. Therefore, automotive and steel companies may require additional specific weldability testing prior to the lubricant's approval with respect to weldability.

4.2 Reference Document

4.2.1 1. A/S P Weld Quality Test Method Manual, Rev. No. 1, 10/31/97, Auto/Steel Partnership, 1997.

4.3 Equipment

The resistance spot welding Current Break-Through Screening Test is conducted with equipment described in Section 6 of the Auto/Steel Partnership (A/S P) Weld Quality Test Method (WQTM) Manual (Ref. 1).

The welding electrodes are:

- Type 2 as shown in Appendix A of the A/S P WQTM Manual when testing a “wet” lubricant, or
- The type specified in Table 5.2 (Welding Parameters) of the A/S P WQTM Manual depending on sheet thickness if testing a “dry” lubricant.

4.4 Testing Materials

4.4.1 Definitions

4.4.1.1 Peel Test Coupon- a coupon, cut from a coupon strip (see Figure 3.4.3.a in the A/S P WQTM Manual) in accordance with Table 3.1.1 (see A/S P WQTM Manual) with its length parallel to the direction of rolling. They are used to make up a peel test sa

4.4.1.2 Peel Test Sample- A lap-joint test sample, composed of two peel test coupons having a specified overlap and standard size, used to perform the Weld Current Break-Through Tests.

4.4.1.3 Wet Lubricants- Mill oils, pre-lubes, drawing compounds, blankwash lubricants, and tapping fluids are all considered to be “wet” lubricants in this screening test.

4.4.1.4 Dry Lubricants- Dry film lubricants and prephosphates are considered to be “dry” lubricants in this screening test.

4.4.2 Peel Test Coupons for “Wet” Lubricant Testing

Material for the peel test coupons described below should be customer approved galvanized and galvanized steel with approved mill oil.

The following dimensions are specified in Section 3 of the A/S P Weld Quality Test Method (WQTM) Manual . Peel test coupons should be sheared and labeled as per sections 3.3 through 3.6 of the A/S P WQTM Manual (Section 3.4.4 is not applicable).

0.80 mm through 0.89 mm material thickness range-Hot Dipped Galvanized (45A/45A), 30mm x 100mm; approximately 172 coupons

0.80 mm through 0.89 mm material thickness range-Hot Dipped Galvanized (60G/60G), 30mm x 100mm; approximately 172 coupons

These peel test coupons will be used for:

- Assembling control peel test samples, and
- Preparing peel test samples with the lubricant under test.

Refer to Table 4.1 to determine the number of coupons required for the various sections of the Weld Current Break-Through Test.

4.4.3 Peel Test Coupons for “Dry” Lubricant Testing

The dry lubricant will be tested as received. This dry film lubricant should have been applied over a customer approved steel (referred to as substrate). The control should be substrate from the same coil(s) used to produce the dry lubricant.

Depending on sheet thickness, the dimensions for the control and dry lubricant peel test coupons are specified in Section 3 of the A/S P WQTM Manual. These coupons should be sheared and labeled as per sections 3.3 through 3.6 of the A/S P WQTM Manual (Section 3.4.4 is not applicable).

Refer to Table 4.1 to determine the number of coupons required for the various sections of the Weld Current

Break-Through Test.

4.4.4 Lubricant

The lubricant supplier shall furnish a statement that the lubricant to be tested is representative of the manufacturing method and composition of that which will be supplied for production material. Dilution ratios, and other lubricant specifications required by the customer shall be recorded on a form which must be attached to the test report.

Table 4.1: Number of peel test Coupons Required for testing

Reference Section	Description	Wet Lubricant Galvanneal	Wet Lubricant Galvanized	Dry Lubricant
4.6.1.5	I_{CBT} Determination			
	Initial Weld (w/o lube)	2	2	2
	Procedure a,b (w/o lube)	-40 ⁽¹⁾	-40 ⁽¹⁾	-40 ⁽¹⁾
4.6.1.6	Weld Current Break Through Samples			
4.6.1.6.1	5 Control Samples (w/o lube)	10	10	10
4.6.1.6.2	10 Test Samples (w lube)	20	20	20
4.6.1.6.3	4T Weld - Control (w/o lube)	4	4	4
4.6.1.6.4	4T Weld - (w/lube)	4	4	4
4.6.1.6.5	3T Weld - Control (w/o lube)	3	3	3
4.6.1.6.6	3T Weld (w/lube)	3	3	3
	Total for Fresh Lubricant	86	86	86
	Total for Aged Lubricant	86	86	86
	Total Coupons Required	172	172	172

Notes: (1) This provides for 20 samples - more or less may be required.

4.5 Test Preparation

4.5.1 Peel Test Coupon Preparation with Lubricant

Peel Test Coupons to be tested with lubricant shall be prepared in the following manner depending on which lubricant is being tested:

Mill Oil- Follow steps 1 and 2.

Pre-lube- Follow steps 1 and 2.

Drawing Compound- Follow step 2.

Blankwash- Follow step 2.

Tapping Fluid- Follow step 2.

Dry Film- Test as received. For aging, see Section 4.5.3 below.

Prephosphate- Test as received. For aging, see Section 4.5.3 below.

Step 1: Clean both sides of peel test coupon with toluene using a clean lint-free cloth, followed by a toluene rinse.

Step 2: Apply lubricant as described in Section 4.5.2 below.

4.5.2 "Wet" Lubricant Application

Since the peel test coupons will require lubricant application on both sides, it will be necessary to support both ends of the coupons such that their bottom side will be off the work surface after coating with lubricant. One possibility is to use various sizes and lengths of angle iron to accomplish this.

Place the peel test coupons flat with both ends supported off the work surface. The top surface ID mark should be facing up. Using a pipette, transfer two(2) ml of lubricant that has been thoroughly mixed, to the top surface of the required number of peel test coupons. Spread the lubricant out evenly over the top surface of each peel test coupon using an index finger (the use of a latex glove is highly recommended). Age horizontally for 1 hour at room temperature. After 1 hour, examine the peel test coupons. If local puddling or streaking of the lubricant has occurred, spread it out evenly over the top surface of the peel test coupons. Age horizontally at room temperature for an additional 30 minutes.

Next, carefully turn over the peel test coupons and lay them flat such that both ends are supported off the work surface. The surfaces with the ID mark and lubricant on it should be facing down. Using the previously mentioned procedure, apply lubricant uniformly in the same manner as was used to coat the other side.

Allow the peel test coupons to age 72 hours at room temperature before conducting the Weld Current Break-Through Test for the “fresh” lubricant.

Lubricant shall be aged (accelerated aging) for the Weld Current Break-Through Test by placing the required number of peel test coupons coated with lubricant on both sides as previously described, into an oven at 49 degrees C (120 degrees F) for 168 hours (7 days). It is not necessary to age them for 72 hours at room temperature before placing them into the oven. The peel test coupons will have to lay flat in the oven with both ends of each coupon supported such that lubricant on the bottom surface of the coupons does not touch the bottom or rack(s) in the oven.

Control coupons without lubricant that are to be used for the aged portion of the Weld Current Break-through Test should also be placed into an oven at 49 degrees C (120 degrees F) for 168 hours (7 days).

4.5.3 Aging of “Dry” Lubricant Peel Test Coupons

The required number of peel test coupons with dry lubricant should be placed into an oven at 49 degrees C (120 degrees F) for 168 hours (7 days).

Control coupons without dry lubricant that are to be used for the aged portion of the Weld Current Break-through Test should also be placed into an oven at 49 degrees C (120 degrees F) for 168 hours (7 days).

4.6 Weld Current Break Through Screening Test Procedure

4.6.1 Galvanneal Samples with Fresh “Wet” Lubricant

4.6.1.1 Electrode Installation- Install the electrodes according to section 7.1 of the A/S P WQTM Manual.

4.6.1.2 Electrode Dressing- Minimal electrode dressing is required to achieve electrode face parallelism and the proper face diameter. Lack of electrode face parallelism can result in uneven pressure on the test lubricant, possibly causing erroneous weld

a). If the electrode face diameters of the installed electrodes (measured prior to installation) fall within the +/- 0.1 mm tolerance, go to Section 7.5 of the A/S P WQTM Manual and follow its instructions. If gross lack of parallelism is evident, dressing with a file (per Section 7.3.1.1) may be required.

b). If the electrode face diameters of the installed electrodes (measured prior to installation) do not fall within the +/- 0.1 mm tolerance, electrode dressing shall be performed as per Sections 7.3.1.1, 7.3.1.2, 7.3.1.3 or 7.3.1.4, 7.5, and 7.5.4 of the A/S P WQTM Manual. These are minimal steps needed to assure electrode face parallelism and the correct electrode face diameter. If the electrode face diameter does not fall within the tolerance of +/- 0.1 mm and/or there are still indications of lack of parallelism, an additional dressing may be required or the electrodes may have to be replaced. Refer to Section 7.3.2 of the A/S P WQTM Manual for second dressing instructions.

4.6.1.3 Welding Parameters- The following weld schedule, taken from Table 5.2 of Section 5 in the A/S P WQTM

Manual, shall be used:

Electrode Force: 2.2 kN (495 lbs.)

Squeeze Time: Adjust as needed to ensure force is greater than or equal to 98% of static force value at initiation of welding current.

Weld Time: 12 cycles

Hold Time: 90 cycles

Cooling: 4.0 l/min

Weld Current: The following default initial welding current is taken from Table 8.3.1 of Section 8.3 in the A/S P WQTM Manual- 6 kA for galvaneal. Allowable % heat or % current settings on the weld control shall be greater than or equal to 60% and less than or equal to 92%.

4.6.1.4 Electrode-Face and Weld-Size Stabilization Procedure- It is not necessary to condition the electrodes for the Weld Current-Break-Through Test.

4.6.1.5 Determination of the Current Break-Through Test Current (ICBT) for Galvaneal Samples- The welding current that is to be used to weld the Current Break-through samples is designated as ICBT. ICBT is defined as the current that produces a weld size

After completion of electrode installation and electrode dressing, one single-weld galvaneal peel test sample (see Figure 1) without lubricant shall be welded at approximately 6 kA. Use Code C orientation throughout the Current Break-through Test (Refer to Figure 5.5.1 in the A/S P WQTM Manual). This weld is then peel-tested and measured using standard A/S P procedures (see appropriate sub-sections of Section 5 in the A/S P WQTM Manual). Determine whether a) or b) applies and follow their instructions.

a) If this weld exhibited no expulsion and is smaller than the face diameter of the electrodes, the current is to be increased in increments of approximately 100 amperes, and another single-weld galvaneal peel test sample without lubricant shall be welded and tested until the mean button size equals the electrode-face diameter or expulsion is attained.

b) If this weld exhibited expulsion, the current is to be decreased in increments of approximately 100 amperes, and one single-weld galvaneal peel test sample without lubricant shall be welded and tested until a no-expulsion weld is obtained.

Using the definition for ICBT, examine the data from a) or b) and determine the ICBT current to be used for the galvaneal portion of the Current Break-through Test.

4.6.1.6 Welding the Galvaneal Current Break-Through Samples- Set the welding current to ICBT determined in step 4.6.1.5 above. Enable the print feature on the Weldscope WS20.

4.6.1.6.1 Make one weld on each of five single-weld galvaneal peel control samples without lubricant. A weldscope printout (see Figures 4.2 & 4.3) should be recorded for each of these welds. These control samples are used to establish the typical current trace or output for the machine being used so that the electrical characteristics of the machine's current output do not affect the analysis of the current data of the test material.

4.6.1.6.2 Make one weld on each of ten single-weld galvaneal peel samples with lubricant (see Figure 4.1). A weldscope printout should be recorded for each of these welds.

4.6.1.6.3 Weld a stackup of four galvaneal control coupons without lubricant and record a weldscope printout.

4.6.1.6.4 Repeat 4.6.1.6.3 using galvaneal coupons with lubricant.

4.6.1.6.5 Weld a stackup of three galvaneal control coupons without lubricant and record a weldscope printout.

Repeat 4.6.1.6.5 using galvaneal coupons with lubricant.

Figure 4.1: Current Break-Through Peel Test Samples

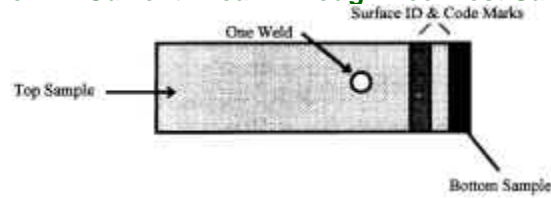


Figure 4.2: Sample Printout of which required No Cycles of Break-Through Time

1	8.42KA	133°	← 120%
	6.80KA	117°	← 98%
2	7.15KA	120°	← 103%
	6.94KA	119°	← 99%
3	7.09KA	120°	
	6.96KA	119°	
4	7.01KA	120°	
	6.91KA	119°	
5	6.97KA	119°	
	6.91KA	119°	
6	6.99KA	120°	
	6.92KA	119°	
7	6.99KA	120°	
	6.92KA	119°	
8	6.97KA	120°	
	6.96KA	119°	
9	7.01KA	120°	
	6.96KA	119°	
10	7.01KA	120°	
	6.99KA	119°	
EFCT CUR. =		6.97KA	
PEAK CUR. =		11.94KA	
CNDT ANGLE =		120°	
DEVIATION =		-30 %	
WELD TIME =		10.0 CY	

Figure 4.3: Sample Printout of Weld which required 2 Half-Cycles of Break-Through Time

1	1.31KA	92°	← 19%
	5.11KA	116°	← 73%
2	6.41KA	120°	← 91%
	6.47KA	117°	← 92%
3	6.70KA	119°	
	6.62KA	117°	
4	6.86KA	120°	
	6.83KA	119°	
5	6.96KA	119°	
	6.94KA	119°	
6	7.12KA	120°	
	7.02KA	120°	
7	7.15KA	122°	
	7.04KA	120°	
8	7.18KA	120°	
	7.15KA	120°	
9	7.29KA	122°	
	7.18KA	120°	
10	7.31KA	122°	
	7.20KA	120°	
EFCT CUR. =		7.03KA	
PEAK CUR. =		12.30KA	
CNDT ANGLE =		121°	
DEVIATION =		-29 %	
WELD TIME =		10.0 CY	

4.6.2 Galvanized Samples with Fresh “Wet” Lubricant

4.6.2.1 Section 4.6.1 of this Procedure is repeated, using galvanized steel instead of galvaneal. Start with Section 4.6.1.1- Electrode Installation. After completion of electrode installation and electrode dressing, start

welding a single-weld galvani

4.6.3 Galvanneal Samples with Aged “Wet” Lubricant

4.6.3.1 Remove the galvanneal control coupons without lubricant and galvanneal coupons with lubricant from the oven after 168 hours (7 days) accelerated aging and allow to cool to room temperature. Perform this test by following Section 4.6.1 except that

4.6.4 Galvanized Samples with Aged “Wet” Lubricant

4.6.4.1 Remove the galvanized control coupons without lubricant and galvanized coupons with lubricant from the oven after 168 hours (7 days) accelerated aging and allow to cool to room temperature. Perform this test by following Section 4.6.1 except that

4.6.5 Fresh Dry Lubricant

4.6.5.1 Electrode Installation- Install the electrodes according to Section 7.1 of the A/S P WQTM Manual.

4.6.5.2 Electrode Dressing- Refer to Section 4.6.1.2 of this Procedure.

4.6.5.3 Welding Parameters- The following weld schedule shall be used (refer to Section 5.2 of the A/S P WQTM Manual):

Electrode Force: Obtain from Table 5.2 depending on sheet metal thickness.

Squeeze Time: Adjust as needed to ensure force is greater than or equal to 98% of static force value at initiation of welding current.

Weld Time: Obtain from Table 5.2 depending on sheet metal thickness.

Hold Time: 90 cycles

Cooling: Obtain from Table 5.2 depending on sheet metal thickness.

Weld Current: Use the Default Initial Welding Current from Table 8.3.1 of Section 8.3 in the A/S P WQTM Manual depending on the dry lube substrate. Allowable % heat or % current settings on the weld control shall be greater than or equal to 60% and less than or equal to 92%.

4.6.5.4 Electrode-Face and Weld-Size Stabilization Procedure- It is not necessary to condition the electrodes for the Weld Current-Break Through Test.

4.6.5.5 Determination of Current Break-Through Test Current (ICBT) - Refer to Section 4.6.1.5 of this Procedure. Use the peel test coupons without dry lubricant. Start welding at the default initial welding current.

4.6.5.6 Welding the Dry Lubricant Current Break-Through Samples - Refer to Section 4.6.1.6 of this Procedure. Use substrate peel test coupons for control samples and substrate with dry lubricant peel test coupons as appropriate.

4.6.6 Aged Dry Lubricant

Remove the substrate control coupons without lubricant and the substrate with dry lubricant coupons from the oven after 168 hours (7 days) accelerated aging. Allow to cool to room temperature. Perform the test by following Section 4.6.5 of this Procedure except that the aged coupons will be used.

4.6.7 Analyzing the Welding Current Data

Using the WS20 printout or strip chart trace for each weld of the test and control materials, calculate the percentage that each half cycle's current is of the mean (effective) current. If it is obvious that the percentage exceeds the minimum current break-through threshold of 90% of the mean (effective) current after several half-cycles, there is no need to calculate the percentage for the remaining half cycles. Each half-cycle that is below the 90% limit is considered not to have achieved current break-through. Count, sum and record the number of half-cycles that are below the 90% minimum for each weld.

Examples of typical WS20 print outputs for two welds and the first four half-cycle percentages are shown in Figures 4.2 and 4.3. Figure 4.2 shows an output for a material where no break-through time was required. The current is already above or nearly 100% of the mean (effective) current (6.97 kA) for each of these half-cycles. Therefore, the current break-through time is 0. Figure 4.3 shows an example where the first two half-cycles do not achieve the minimum threshold of 90% of the mean current. Therefore, the time required to achieve current break-through in this weld is 2 half-cycles.

Unless specified differently by a customer, in order for a wet lubricant to pass, none of the ten galvanized samples and none of the ten galvanized samples (with fresh and aged lubricant) shall require a current break-through time of greater than 1 half-cycle. The control samples (five galvanized and five galvanized samples- "fresh" and "aged") must also meet this criterion.

Likewise, in order for a dry lubricant to pass, none of the ten substrate with dry lubricant samples (with fresh and aged dry lubricant) shall require a current break-through time of greater than 1 half cycle. The control substrate samples (fresh and aged) must also meet this criterion.

NOTE: If the control samples fail and show similar results to the test samples with lubricant, the causes may be the properties of the control material, the instrumentation being used to monitor the welds, the welding machine, and/or operator interpretation of the results. It is the duty of the testing laboratory to ascertain the cause(s) for failure if it is known that the control materials should not fail this test.

4.7 Report

The final report should include the following information:

1. AUTO/STEEL PARTNERSHIP, A/S P-WQET1 WELDING TEST REPORT - Page 1 filled out as appropriate.
2. AUTO/STEEL PARTNERSHIP, TIP IMPRINT DATA SHEET DOPT1- Page 1 filled out as appropriate.
3. Welding Current and Weld Button Data from Determination of the Current Break-Through Test Current ICBT - record on AUTO/STEEL PARTNERSHIP, WELDING DATA SHEET. The top section of this form should also be completed.
4. Test Data from Current Break-Through Samples
 - a. Record Welding Current Data on the AUTO/STEEL PARTNERSHIP, WELDING DATA SHEET. In the Remarks Section, include what is being welded. For example, Galvanized Peel Control Sample #1 w/o lube (fresh), Galvanized Test Sample #1 w/ fresh lube, etc.
 - b. Include weldscope printout for all test welds, including control samples. See Figures 4.2 & 4.3 for examples.

The above mentioned standard data sheets are available in the A/S P Weld Quality Test Method Manual (See Section 4.2 - Reference Document).

4.8 Safety

Test operators shall be made aware of any potential exposure to hazardous and toxic materials during handling and welding tests. Generation of fumes caused by thermal effects on the lubricant during welding may produce fumes that contain substances that cause adverse reactions in humans. It is the responsibility of the testing

laboratory and operator to assure that appropriate safety and health precautions are identified, understood and practiced. Any unusual physiological reactions shall be reported and testing shall cease immediately until the source of the reaction is identified.

5.1 Scope

This test method is to determine the effects of sheet metal forming lubricants (prelubes, mill oils, edge coaters, drawing compounds, flex roll oils and corrosion preventatives) on the phosphate system (cleaning & baths and phosphate coating).

5.2 Equipment Required

5.2.1 Twelve (12) sets [six (6) sets for test lubricant and six (6) sets for control lubricant] 100 x 150 mm test panels for each of the following substrates:

Cold Rolled Steel
Electrogalvanized
Hot Dipped Galvanize
Electrogalvanneal
Hot dipped Galvannea

5.2.2 Solvent - Toluene

5.2.3 Draw Bar - #0, and #8 (whichever is appropriate).

5.2.4 Control lubricants: Contact automotive customer to determine controls

5.2.5 Oven, capable of 50 degrees C.

5.2.6 Bottles, 250 ml capacity.

5.2.7 Rack capable of holding test panels vertically with a 25 mm space between panels.

5.2.8 Shield used for indirect water break free (WBF) test. The shield is fabricated from a 150 mm x 150 mm metal test panel. A 12mm hem is formed to allow the shield to be slipped onto the edge of the test panels. The shield is bent at 15 degrees adja

5.3 Panel Preparation

5.3.1 To prepare a mill oil for evaluation follow steps 1, 2, and 6.

5.3.2 To prepare a prelude for evaluation follow steps 1, 3, and 6.

5.3.3 To prepare a draw compound and blankwash for evaluation follow steps 1, 2, 4, 5, and 6.

5.3.4 To prepare a dry film lubricant for evaluation proceed directly to the appropriate test method (no preparation is required).

Step 1 Clean test panels (both sides) using a toluene wipe with the clean lint-free cloth, followed by a toluene rinse.

Step 2 Apply mill oil using #0 draw bar on one side.

Step 3 Apply prelude using #0 draw bar on one side.

Step 4 Place panels in a rack 15 degrees from the vertical position. Age for 24 hours at room temperature.

Step 5 Coat panel with draw compound (at recommended dilution) using draw bar #8 over control mill oil. Age horizontally for 45 minutes at room temperature.

Step 6 Place panels in a rack 15 degrees from the vertical position. Allow to age 72 hours at room temperature prior to corrosion test exposure.

NOTE: Space all panels 50 mm apart on racks. The front panel on each rack should be a protective blank.

5.3.5 Age the control and test panels in an oven for 168 hours at 50 degrees C.

5.4 Test Procedure

Four (4) tests are required; water break free, foaming, emulsification and phosphate coating.

5.4.1 WATER BREAK-FREE (WBF). The objective is to determine the amount of contamination of the test material that the cleaning stage of an approved phosphate system can tolerate before its performance is effected. The test is performed using two methods

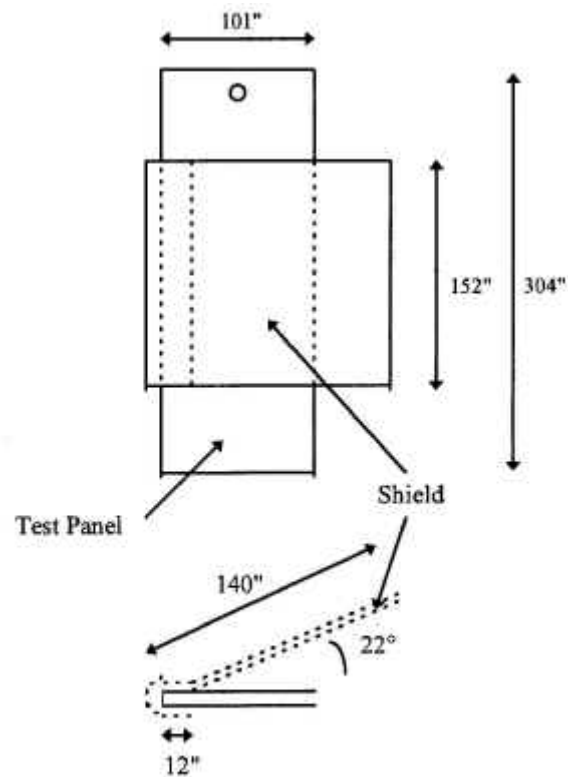
5.4.1.1 Prepare two fresh cleaner baths. One will be used to evaluate the new lubricant and the other bath for the control product. Run two (2) test and two (2) control panels of each substrate through the respective cleaner baths (Reference 5.5 Cleanin

5.4.1.2 Add 1% of the test and control lubricants by weight to each cleaner bath. Run two (2) test panels of each substrate and rate % WBF. Run two (2) test panels with shields and rate % WBF. Compare degree of foaming with fresh cleaner baths per Sect

5.4.1.3 Add test and control lubricant to contaminate the respective cleaner baths to 2% by weight. Run two (2) test panels of each substrate and rate % WBF. Run two (2) test panels with shields and rate % WBF. Compare degree of foaming with fresh clea

5.4.1.4 All test panels should proceed directly through the remainder of the phosphate process after the % WBF rating (Reference Section 5.4.4).

Figure 5.1: Test set-up with indirect shield



Note: Figure is not to scale

5.4.2 FOAMING. The objective is to determine the amount of contamination of the test material that the cleaning stage of an approved phosphate system can tolerate before the foaming of the bath will be effected. During the % WBF test (Reference Section

Example:

% CONTAMINATION	TIMES MORE FOAM
0	-
1	6
2	8-10

5.4.3 EMULSIFICATION. The objective is to determine the rate at which the forming lubricant will separate from an approved phosphate system's cleaning solution.

5.4.3.1 Preparation of Cleaning Solution. Four concentrations of 1.87, 3.75, 7.5 and 15.0 g/l (0.25, 0.5, 1.0, and 2.0 oz. per gallon).

5.4.3.2 Test Conditions. Add 4 mls of test material (lubricant) to 200 mls of each concentration at 63 degrees C in a 250 ml glass bottle. Holding the bottle vertically, agitate vigorously for 10 seconds.

5.4.3.3 Rate the percent of separation at 5 minutes, 60 minutes and 24 hours.

5.4.3.4 Example:

Cleaner Concentration		5 MIN	60 MIN	24 HOURS
g/l	OZ/GAL	%	%	%
1.87	0.25	100	-	-
3.75	0.5	100	-	-
7.5	1.0	50	100	-
15.0	2.0	0	50	100

5.4.4 PHOSPHATE The objective of this test is to rate the panels that have been cleaned in the water break-free (%WBF) test for their phosphatability. Treat all the panels from the % WBF test in an approved phosphate bath solution (spray applied or immerse)

Immediately after the final water rinse and before drying, these surfaces shall exhibit a continuous water film without mapping.

Prior to rating panels, dry at 100 degrees C for 15 minutes.

The dried phosphate coating shall be evaluated for uniformity/mapping on all substrates.

Photographs are taken at 200X and 1000X magnification with a scanning electron microscope to evaluate coating continuity and crystal size (no visible voids are permitted in the applied coating).

Crystal Size:

Small.....3 - 6 microns
 Medium.....5 - 12 microns
 Large..... > 12 microns

Coating Weights

Cold Rolled Steel
 Electrogalvanized
 Hot Dipped Galvanized
 Electrogalvanneal
 Hot Dipped Galvanneal

Units g/m² (per side)

1.1 - 2.7
 1.6 - 3.3
 1.6 - 3.3
 2.2 - 3.8
 2.2 - 3.8

5.5 Mapping

Run samples through an approved electrodeposition bath and evaluate samples for mapping after electrocoating.

5.6 Cleaning and Phosphate Process

5.6.1 For a general cleaning and phosphate sequence, contact your in-plant Phosphate Supplier.

6.1 Scope

This test method is designed to determine the effects of sheet metal processing fluids (corrosion preventatives, drawing compounds, edge coaters, flex roll oils, mill oils, and prelubes) on the Electrocoat system.

6.2 General Equipment

6.2.1 Appropriate sized oven capable of maintaining 182 degrees C

6.2.2 Micropipette with disposable tips capable of delivering 15 microliters and 140 microliters (+/-0.5 microliters)

6.2.3 Kimble Opticlear clear 0.75 ml glass vial (code no. 60831D-830)

6.2.4 Round, unlined metal cans approximately 4 liters in size

6.2.5 200 mm x 200 mm square 100 X 100 mesh aluminum screens

6.2.6 100 mm x 100 mm square 6.35 mm (1/4") grid wire cloth

6.3 Test Materials

6.3.1 Uncontaminated control Electrocoat bath materials. Contact customer to determine controls prior to initiating testing.

6.3.2 100 mm x 125 mm zinc phosphated cold rolled steel test panels

6.3.3 Control and Test Lubricant; Contact customer to determine control lubricant prior to initiating testing

6.4 Test Set-Up

Run the procedure below excluding the test material (Step 6.5.4) to establish base line data.

6.5 Test Procedure

6.5.1 Preheat oven to 182 degrees C

6.5.2 Electrocoat three (100 mm x 125 mm) panels for each test, control, and base line evaluation at temperature and voltage required to produce appropriate film build.

6.5.3 Let panels air dry for a minimum of five minutes.

6.5.4 Add 15 microliters of test material into the bottom of each of three vials and 15 microliters of control material into the bottom of each of three vials. (exterior of pipette must be wiped clean before delivery to vial)

6.5.5 Add 140 microliters of deionized water to each of six vials (exterior of pipette must be wiped clean before delivery to vial).

6.5.6 Place one electrocoated panel onto the bottom of each of the six one gallon cans.

6.5.7 Place a vial, upright, onto the center of each of the six panels.

6.5.8 Place the cans, with panels and vials, into the preheated oven and cover each can with 200 mm x 200mm square screen (minimize time with oven door open).

6.5.9 Bake for 10 minutes at 182 degrees C.

6.5.10 Remove cans from oven and let them cool.

6.5.11 Remove panels from cans and discard vials.

6.6 Evaluation and Results

6.6.1 Place a 100mm x 100mm square wire cloth over panel, centering the screen over vial mark.

6.6.2 Count every screen square in which a crater lies. (disregard the vial mark)

6.6.3 Calculate the percentage of squares with craters.

6.6.4 Rate each panel according to the following scale:

A= 0 - 10%

B=11 - 20%

C=21 - 40%

D=41 - 80%

E= greater than 80%

6.7 Report

6.7.1 Report the range of results for all three panels for the test and control materials. If the individual results for the three replicate panels span three or more categories, repeat the test and report the final rating based only on the second test r

6.7.2 Note the type of craters present, for example: pinpoint only, clusters noted, and/or fish eyes noted.

6.8 Safety

This method may involve hazardous materials, operations, and equipment. This method does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7.1 Scope

This test procedure describes a method to evaluate new metal forming lubricants, including mill oils, drawing compounds, blank washers, prelubes, and dry film lubricants, to determine a minimum level of compatibility with adhesives and sealers currently in use by automotive manufacturers. This procedure does not substitute for the approval process for lubricants, but is only an abbreviated test for establishing feasibility.

This procedure has two Phases, initial and environmental. Evaluate the initial data before proceeding to Phase 2.

Confirm control materials prior to initiating tests.

7.2 Referenced Standards

ASTM D1212
S'E J1523
ASTM D5573

ASTM D4147
ASTM D1876
ISO 10365

7.3 Equipment

7.3.1 Universal tensile test machine

7.3.2 Air circulating oven, capable of maintaining temperature at +- 2 degrees C.

7.3.3 #0 Draw bar or equivalent. Typical applied coating weight is 3 - 6 g/m² per side Actual range is lubricant formulation specific.

7.3.4 #8 Draw bar or equivalent. Typical applied coating weight is 13 - 19 g/m² per side. Actual range is lubricant formulation specific.

7.3.5 0.25 mm diameter glass beads

7.3.6 1.0 mm diameter stainless steel wire

7.3.7 25 mm binder clips

7.3.8 Analytical balance.

7.4 Test Materials

7.4.1 Test Panels

7.4.1.1 25 X 100 X 0.8 mm 60/60 hot dipped galvanized minimum spangle free steel

7.4.1.1 25 X 100 X 0.8 mm A40, two-sided galvanized steel

7.4.1.3 25 X 300 X 0.8 mm 60/60 hot dipped galvanized, minimum spangle free steel

7.4.1.4 25 X 300 X 0.8 mm A40, two-sided galvanized steel

7.4.1.5 100 X 150 X 0.8 mm 60/60 hot dipped galvanized, minimum spangle free steel.

7.4.1.6 100 X 150 X 0.8 mm A40, two-sided galvanized steel.

7.4.2 CONTROL LUBRICANTS. - Contact customer to confirm control lubricant selection prior to initiating tests.

7.4.3 CONTROL ADHESIVES. - Contact customer to confirm control adhesive selection prior to initiating tests.

7.4.4 CONTROL SEALERS. - Contact customer to confirm control sealer selection prior to initiating tests.

7.4.5 MISCELLANEOUS

7.4.5.1 Toluene.

7.4.5.2 Clean lint-free wiping cloth.

7.4.5.3 Candidate lubricant.

7.5 Test Sample

7.5.1 Test Sample Preparation

Clean test panels using a toluene wipe with the clean lint-free wiping cloth, followed by a toluene rinse.

NOTE: Do not clean dry film lubricant test panels - use as received.

7.5.2 Apply control lubricants as follows, using the procedure for the draw bar described in ASTM D4147. Use draw bars specified or as appropriate to obtain the specified coating weight.

Control drawing compound #1, draw bar #8, over control mill oil, draw bar #0.

Control drawing compound #2, draw bar #8, over control mill oil, draw bar #0.

Control pre-applied lubricant, draw bar #0.

No lubricant.

7.5.3 Apply candidate lubricant at the lowest recommended dilution (i.e., highest percent solids), if any, according to the appropriate type, using the procedure for the draw bar described in ASTM D4147. Report actual dilution. Use draw bars specified

Drawing Compound:

Candidate lubricant, draw bar #8, over control mill oil, draw bar #0

Blank Wash:

Candidate lubricant, draw bar #8, over control mill oil, draw bar #0

Mill Oil:

Control drawing compound #1, draw bar #8, over candidate lubricant, draw bar #0.

Control drawing compound #2, draw bar #8, over candidate lubricant, draw bar #0.

Pre-applied Lubricant:

Candidate lubricant, draw bar #0

Dry Film Lubricant:

Candidate lubricant, pre-applied to metal by steel mill or roll coater at maximum production coating weight recommended by supplier and OEM. Report actual coating weight.

NOTE: Lab application of dry film lubricant may be acceptable if agreed upon by supplier and OEM.

7.5.4 Allow lubricant(s) to air dry horizontally for 2 hours min., 24 hours max.

7.5.5 Confirm lubricant coating weight application on three (3) 100 x 150 mm test panels per lubricant/substrate combination using procedure found in 7.6.1 prior to coating test samples.

7.5.6 Structural adhesive is applied to one side of one (1) of the 25 x 100 mm test panel to cover the 25 X 12.7 mm overlap area. Sprinkle with less than 1% by weight glass beads to maintain bondline thickness. Mate coupons and clamp. Remove any squeez

7.5.7 Pumpable sealer is applied to one side of one (1) of the 25 x 300 mm test panel to cover the 25 x 228 mm bond area. Place three (3) 1.0 x 25 mm wire spacers on test panel. Place the second panel on top and clamp with three (3) binder clips positio

7.5.8 Die cut sealers, apply a 25 x 228 x 1.6 mm, or thickness as supplied, strip.

7.5.9 Dwell time for all samples prior to oven cure is 2 hours.

7.5.10 Cure single overlap shear and T-peel samples in an air circulating oven for 20 minutes at 180 degrees C oven temperature.

7.5.11 Remove clamps. Remove any additional squeeze-out from sealer test samples.

7.5.12 Condition sample at ambient for 24 hours minimum.

7.6 Test Procedures

7.6.1 WEIGH-STRIP-WEIGH TEST METHOD FOR MEASUREMENT OF COATING WEIGHT.

7.6.1.1 After lubricant application and dry time, weigh the 100 X 150 mm panel to the nearest 0.1 mg on an analytical balance.

7.6.1.2 Degrease coupon using appropriate technique. (see 4.1.1)

7.6.1.3 Reweigh the panel to the nearest 0.1 mg.

7.6.1.4 Calculate lubricant coating weight in g/m²

$$\text{Coating weight} = \frac{\text{Weight loss}}{\text{Total Area}}$$

7.6.1.5 Calculate coating weight mean and standard deviation.

7.6.2 STRUCTURAL ADHESIVES - SINGLE OVERLAP SHEAR ADHESION TEST (S'E J1523). Test samples in a universal tensile tester, 12.7 mm/minute pull rate.

7.6.3 SEALERS - PEEL RESISTANCE OF ADHESIVES (T-PEEL TEST) (ASTM D1876). Test samples in a universal tensile tester, 127 mm/minute pull rate.

7.6.4 CORROSION CYCLE (PHASE 2). Test after 30 cycles.

15 minutes salt water immersion (5% salt solution)

1 h + 45 minutes drip dry under ambient conditions

22 h in 50 +/- 1 degrees C, 90% RH chamber

Condition 1 h min., 24 h max. under ambient conditions prior to testing.

7.7 Evaluation and Results

SINGLE OVERLAP SHEAR TEST. Determine individual peak loads, average peak load, standard deviation, and failure mode, as defined in ISO 10365 or ASTM D5573.

T-PEEL TEST. Determine maximum, minimum, and average peel load, as defined in ASTM D1876, with five (5) equally spaced measurements. Record failure mode as defined in ISO 10365 or ASTM D5573.

7.8 Report (Including the following:)

7.8.1 Complete identification of the candidate and control lubricants, adhesives, substrates, and sealers: manufacturer, roll coater, product code, lot number, tested concentration or dilution, etc.

7.8.2 Conditioning of test specimen.

7.8.3 Test conditions: temperature and humidity.

7.8.4 Complete identification of "equivalent" equipment, if used.

7.8.5 Weight for each lubricated panel, degreased panel, and weight loss; mean and standard deviation for coating weight (g/m²), including procedure used.

7.8.6 Test results, with any observations.

7.8.7 Record any variations made to this procedure.

NOTE: To be acceptable, variations to the procedure must be agreed upon by supplier and OEM.

7.9 Safety

This method may involve hazardous materials, operations and equipment. This method does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.