SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

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SAE No. 2 Friction Test Machine 3600 r/min Stepped Power Test

RATIONALE

Removal of North American OEM standard references in line with their unavailability and/or obsolescence.

1. SCOPE

This SAE Recommended Practice is intended as the definition of a standard test, but may be subject to frequent change to keep pace with experience and technical advances. This should be kept in mind when considering its use.

The SAE No. 2 Friction Test Machine is used to evaluate the friction characteristics of automatic transmission plate clutches with automotive transmission fluids. It can also be used to conduct durability tests on wet friction systems.

The specific purpose of this document is to define a 3600 r/min Stepped Power Test for the evaluation of wet friction system performance variation as a function of power level. This procedure uses an initial engagement speed of 3600 r/min and is intended as a standard procedure for common use by both suppliers and end users.

The only variables selected by the supplier or user of the friction system are:

a. Friction Material

b. Fluid

c. Reaction Plates

These three variables must be clearly identified when reporting the results of using this test. If any of the test parameters or system hardware as described in this document are changed, other than the friction material, test fluid, or reaction plates, the data may not be reported as having been obtained using this document.

This procedure is not intended to evaluate the initial coefficient or break-in characteristics. For this information, refer to SAE J2490 SAE No. 2 Friction Test Machine μPVT Test.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J286 SAE No. 2 Clutch Friction Test Machine Guidelines

SAE J1646 Glossary of Terms—Lubricated Friction Systems

SAE J2490 SAE No. 2 Friction Test Machine μPVT Test

2.2 Related Publications

The following publications are for information purposes only and are not a required part of this specification.

2.2.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1499 SAE Band Friction Test Machine (SAE) Test Machine Guidelines

SAE Paper 670051 New Fixture for Testing Friction Materials for Automatic Transmission Clutch

SAE J2488 SAE No. 2 Friction Test Machine 6000 r/min Stepped Power Test

SAE J2489 SAE No. 2 Friction Test Machine Durability Test

3. TEST EQUIPMENT

3.1 SAE No. 2 Friction Test Machine with breakaway accessory.

3.2 Flywheels to deliver desired kinetic energy. The flywheels required to provide the specified step changes in total system inertia are shown in Tables 1A and 1B.

3.3 Data Acquisition

At not less than 1000 samples per second and storage system with at least four channels with response as follows:

a. Torque Channel, Bandwidth – 500 Hz.

b. Apply Pressure Channel, Bandwidth – 500 Hz.

c. Speed Channel, Bandwidth – 500 Hz.

d. Test Fluid Temperature Channel, Bandwidth – 3 Hz.
(All channels are to be calibrated to maintain ±2% accuracy throughout the range of 10% of full scale to full scale).

3.4 Instrumentation

a. Torque Transducer—Full bridge, strain gage type, with combined nonlinearity and hysteresis effects not to exceed 0.5% of full scale, such as Lebow Load Cell, Model 3397.

b. Apply Pressure Transducer—Full bridge, strain gage type, with combined nonlinearity and hysteresis effects not to exceed 0.5% of full scale, such as Sensotech, Model TJU708-12.

c. Speed Transducer—Optical Encoder for drive motor, such as BEI Model 924-01002-4839.

d. Thermocouple(s)—Type J with high-impedance amplifier and cold junction compensator.

TABLE 1A - REQUIRED INERTIA
3600 R/Min INITIAL SPEED

Step Level	Total Inertia (kg-m^2)	Incremental Flywheel Inertia (kg-m^2)	Possible Flywheels	Energy
1	0.213	Motor+A	A	15.13
2	0.254	0.041	A+B	18.02
3	0.294	0.040	A+2B	20.91
4	0.335	0.041	A+C	23.80
5	0.376	0.041	A+B+C	26.69
6	0.416	0.040	A+2B+C	29.58
7	0.457	0.041	A+D	32.47
8	0.498	0.041	A+B+D	35.36
9	0.538	0.040	A+2B+D	38.25
10	0.579	0.041	A+C+D	41.15
11	0.620	0.041	A+B+C+D	44.04
12	0.660	0.040	A+2B+C+D	46.89

TABLE 1B - POSSIBLE FLYWHEELS REQUIRED FOR THE TEST

Code	Quantity	Inertia (kg-m^2)
A	1	As required to achieve Level 1 inertia of 0.213
B	2	0.0405
C	1	0.1215
D	2	0.2430

3.5 Test Fluid System

(Figure 1C in SAE J286) Heated sump including immersion or jacket heater with sufficient watt density for test fluid temperature control and the associated hardware for external fluid flow control. Care should be taken that the fluid is not altered or modified by contact with the immersion heater by ensuring that the heater does not exceed a power density of 2 W/cm^2.

3.6 Adapters and Reaction Plates

The required friction, reaction plates, hub, retainer and pressure plates and spacers are all described in Appendix A.

3.7 Apply Piston Seal

a. VITON®

b. Teflon®—Recommended for use in high temperature fluid tests.

3.8 Lubrication System Flow Configuration

3.8.1 External FLow

(Figure 1C in SAE J1646). This represents the configuration wherein an external pump supplies fluid at a specific flow rate through a line to the centerline of the shaft. A flow meter must be installed in the line to the cover to measure the flow supplied to the head. The drain to the sump is located at the 5, 6, and 7 o'clock positions.

4. TYPICAL OPERATING CONDITIONS AND TEST PARAMETERS

4.1 Piston Area

15 110 mm^2.

4.2 Piston Available Travel

4.57 mm.

4.3 Piston Apply Pressure

As required to produce the required stop time of 0.5 s for each engagement. Allowable variation in stop time is ±0.5% or ± 3.0 ms (see Reference SAE J1646 for definitions).

a. Start Threshold – Torque

b. Stop Threshold – Torque

4.4 Piston Apply Pressure Rise

The apply pressure must be stable at the required level within 50 ms. (Highest pressure level) The maximum overshoot must not exceed 2% of the required pressure level.

4.5 Piston Release Pressure

30 to 100 kPa and must be 0 kPa during the apply period.

4.6 Effective Inertia Range

The inertia range is from the effective base Inertia, which is the minimum inertia for the test, to some maximum as determined in the test. A flywheel specific to an individual dynamometer may be required to attain the Level 1 inertia of 0.213 kg-m^2. See Tables 1A and 1B.

4.7 Initial Engagement Speed

3600 r/min +0/–20 r/min.

4.8 Kinetic Energy

As shown in Tables 1A and 1B and Appendix B. These kinetic energy values must be as required for the specific level. The allowable variation in kinetic energy is ±5%.

4.9 Breakaway Speed

4.37 r/min.

4.10 Test Fluid

a. Quantity—18 L minimum, and must be replaced with new fluid at the beginning of the procedure.

b. Temperature—115 °C ± 5 °C. Measured in the inlet line as shown in Appendix A.

c. Test Fluid Flow—The test fluid flow rate is 0.5 L/min ± 0.05 L/min.

d. Fluid Flow Configuration—The flow configuration is External Flow as described in SAE J1646 and 3.8.

4.11 Pack Clearance

1.143 mm ± 0.127 mm

4.12 Test Periods

Refer to SAE J1646 for the definitions of the test periods. The total period for one dynamic engagement cycle is 30 s ± 1 s.

a. T_1, Stabilization Period—15 s ± 0.5 s

b. T_2, Coast Period—0

c. T_3, Apply Period—12 s ± 0.1 s

d. T_4, Dwell Period—3 s ± 0.5 s

e. T_5, Soak Period—2.5 s ± 2.5 s

f. T_6, Breakaway Period—2 s ± 0.5 s

g. T_7, Cooling period—0

4.13 Test Description

The procedure, as described in detail in Appendix A, consists of increasing steps of power, each level consisting of 200 engagements and one breakaway. Inspections are made of the reaction plates and friction assemblies at the end of each level. The different power levels are achieved by increasing the effective inertia while the stop time and initial engagement speed are kept constant at 0.5 s and 3600 r/min, respectively. The test is run at increasing power steps until the friction system has completely failed.

5. GENERAL TEST INFORMATION

5.1 Clean

Prior to each test, the fixture and sump must be cleaned thoroughly and fixture and sump washed with solvent. The sump is then filled with the new test fluid.

5.2 Inspect

Inspect rotating shaft seal for deterioration and replace, if necessary. If this seal is replaced, also replace the nonrotating lip seals.

5.3 Soak

Soak friction elements in the test fluid for at least 10 min at room temperature.

5.4 Measure and Record

Measure and record the thickness of each friction element, after 5.3 before test and again after each test level at the same predetermined locations. A minimum of three locations, 120 degrees apart, at the approximate mean radius are to be identified by a durable mark and used for all measurements. The measurements from the various locations for each element are averaged and also averaged for the elements. These average changes in thickness from the original thickness are reported as the average cumulative loss of thickness.

Measurements are made with a flat anvil meter with a 3.175 mm minimum diameter and ±0.0127 mm accuracy.

5.5 Mark Surfaces

Mark mating surfaces on the tab face of splines in sequence of assembly for orientation of the friction assemblies and reaction plates. The clutch pack must be disassembled and reassembled with the exact same orientation of the component with respect to each other and to the stationary splines in the housing. All markings should be visible from the cover end of the housing.

5.6 Install Clutch Pack

Install a reaction plate to contact the pressure plate. Follow with a friction assembly, reaction plate, and so on until all the required components have been installed. The last plate to be installed must be a reaction plate. Its thickness (spacer) must be selected to ensure that the pack clearance is as defined in 4.11. The pack configuration is PRFRFRFRSC, where P is the Piston, R is a Reaction plate, F is a Friction assembly, S the Spacer plate (as required), and C the Cover. Reaction plates may be used as the spacer.

Verify axial alignment of Hub oil holes and friction plates (see Appendix A).

5.7 Install Housing Cover

Start the circulation pump and the temperature controller to heat the fluid and internal elements to the required control temperature, as given in 4.10.

5.8 Install Flywheels

Install the flywheels required to achieve the effective inertia required for the power level to be evaluated.

5.9 Check Fluid Flow and Temperature

With the motor off, check that the fluid control temperature and the flow rate are as given in 4.10.

5.10 Start Test

Initiate the testing for the required level as defined in Appendix B. Determine pressure level to achieve the required 0.5 s stop time, as defined in 4.3.

a. Always set the pressure to the low side of the estimated value as the test is to be aborted if the stop time EVER falls below 0.45 s as uncontrolled friction system damage may occur.

b. Initiate the testing for the required level as defined in Appendix B.

c. The stop time MUST be set, per 4.3, by the 20th engagement and maintained during the remaining 180 engagements.

5.11 End of Level Inspection

Shut down test stand. At the completion of the required dynamic engagements and the breakaway measurement, the housing is opened and the clutch pack carefully removed with special attention to ensure that the plates can be reinstalled in the exact same location and order relative to adjoining plates and fixed locations in the housing. Measurements are made of the friction element thickness as noted in 5.4. Observations of the conditions of the reaction plates and friction elements and the fluid are recorded. Photographs may be taken to show the condition of the plates and assemblies.

6. DATA ACQUISITION

6.1 Data Acquisition Rate

For digital data acquisition systems the data is to be recorded at 1000 samples per second per channel using a 15 ms time constant RC filter. (Filtering will slew data. Preferred method is to record all raw data and manipulate later.)

6.2 Coefficient Calculations

Coefficients are calculated for the following dynamic coefficient' at every 25th engagement. (Reference SAE J1646)

a. Midpoint dynamic – $_{50\%}\mu_{d}$

b. Endpoint dynamic – $_{\leq 100ms}\mu_{dMax}$ (Based on raw data single point value)

The breakaway coefficients, obtained every 200 dynamic engagements, is defined as:

Breakaway coefficient – $_{1.0}\mu_{s4.37}$

6.3 Data Averaging and Filtering

Data is to be averaged at the specified location in either the time or speed domain as specified in 6.1 with midpoint coefficient average values calculated using data points ±80 ms on both sides of the required calculation point. Endpoint coefficient average values are calculated from non-filtered peak torque data measured in the last 100 ms of the engagement. For the 1000 Hz-sampling rate, the averages are based on 161 data points.

7. DATA REPORTING

7.1 Data Tables

A data table showing the friction material, spacer plate, and fluid along with the system performance at each level in terms of the coefficients given in 6.2 along with the average wear values and calculated E/M ratio are to be included in the test table. An example Table is given in Appendix B.

7.2 Figures

There are two figures required in reporting the results of this test. Examples of the two figures are given in Appendix C.

a. Figure of the midpoint dynamic coefficient and the cumulative average plate wear versus the level number.

b. Figure of the E/M ratio and breakaway coefficient versus level number.

If the system does not successfully complete both the 200 dynamic engagement and the breakaway test, there is no data reported for that level. Alternatively, only data for the successful completion of a level are to be reported. Failure is defined as complete destruction of the friction material/system. (Report number of cycles into level at which failure occurred.)

7.3 Optional Data

Instantaneous plots of the 50th and 200th dynamic engagements at each level may be provided. Additionally, comments and photographs on the condition of the plates at the end of each level may also be included. Examples of such optional data are shown in Appendix B.

8. NOTES

8.1 Marginal Indicia

The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE AUTOMATIC TRANSMISSION FRICTION STANDARDS COMMITTEE

APPENDIX A

A.1 This appendix contains the following prints describing the friction assembly, reaction plates, adapters, hub and pressure plates required for this test procedure.

TABLE A1 - TEST COMPONENTS AND ASSEMBLY LAYOUT

File Name	Description
ITEM 1	Adapter Ring
ITEM 2	Separator Retainer
ITEM 3	Pressure Plate
ITEM 4	Friction Plate Hub
ITEM 5	Separator Plate
ITEM 6	Friction Plate Assembly
ITEM 7	Retaining Ring (External)
ITEM 8	Retaining Ring (Internal)
ITEM 9	3 Plate Spacer (10.18 Thick)
ITEM 10	4 Plate Spacer (6.45 Thick)
ITEM 11	Splined Hub Spacer
ITEM 12	Spiro-Lock Retaining Ring
	3 Plate Assembly Cross Section
	4 Plate Assembly Cross Section

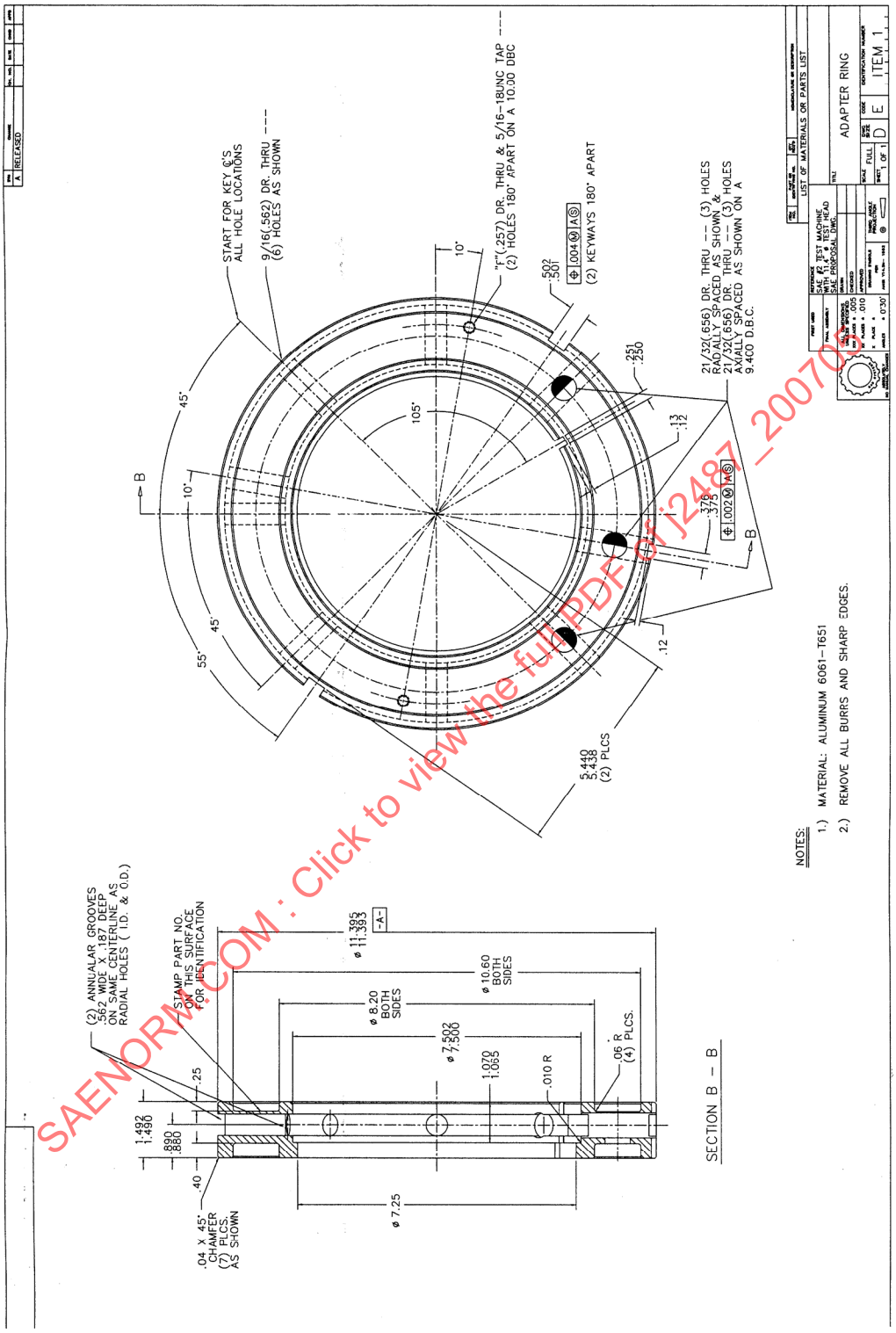

FIGURE A1 - ITEM 1 - ADAPTER RING

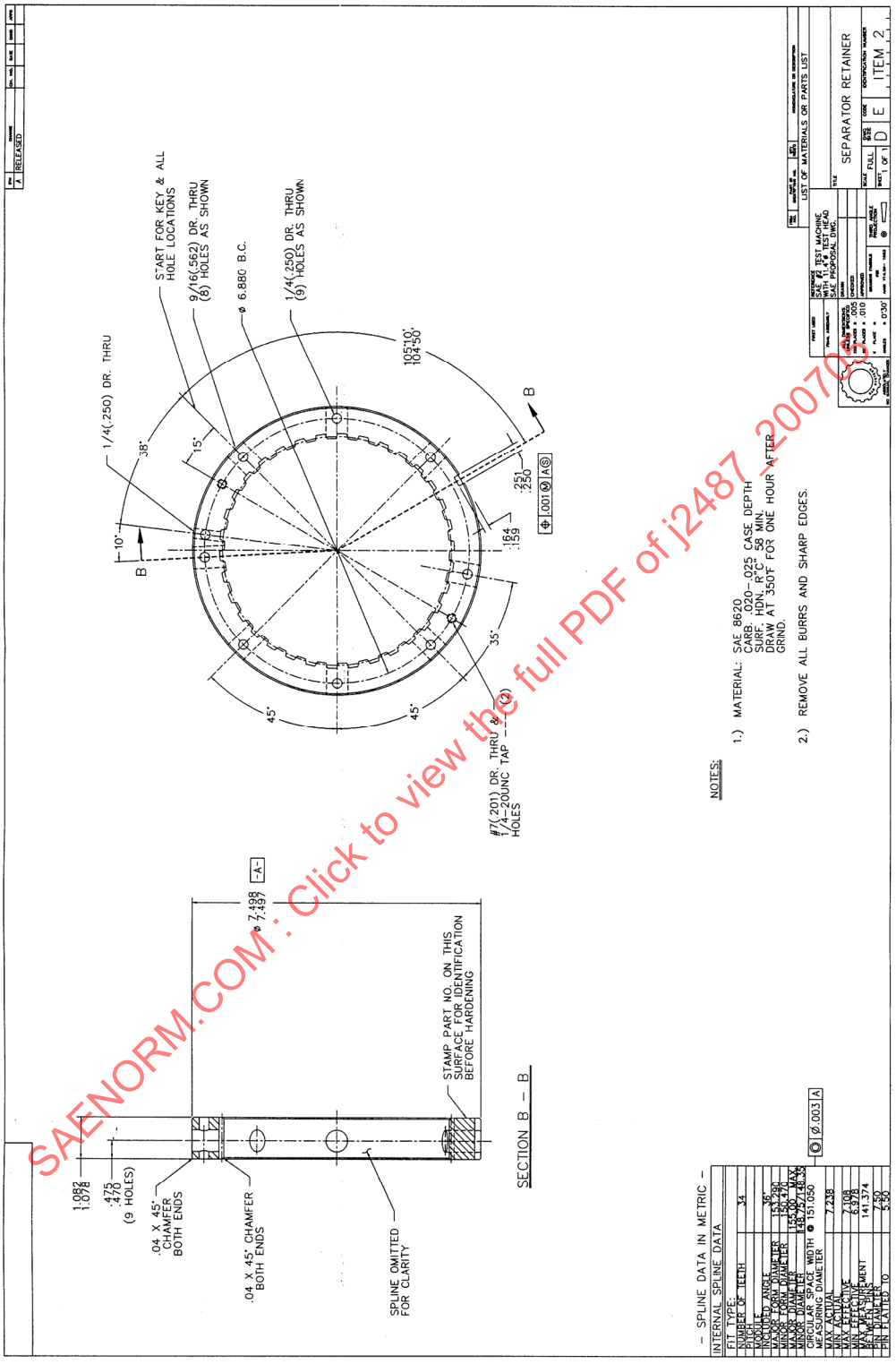

FIGURE A2 - ITEM 2 - SEPARATOR RETAINER

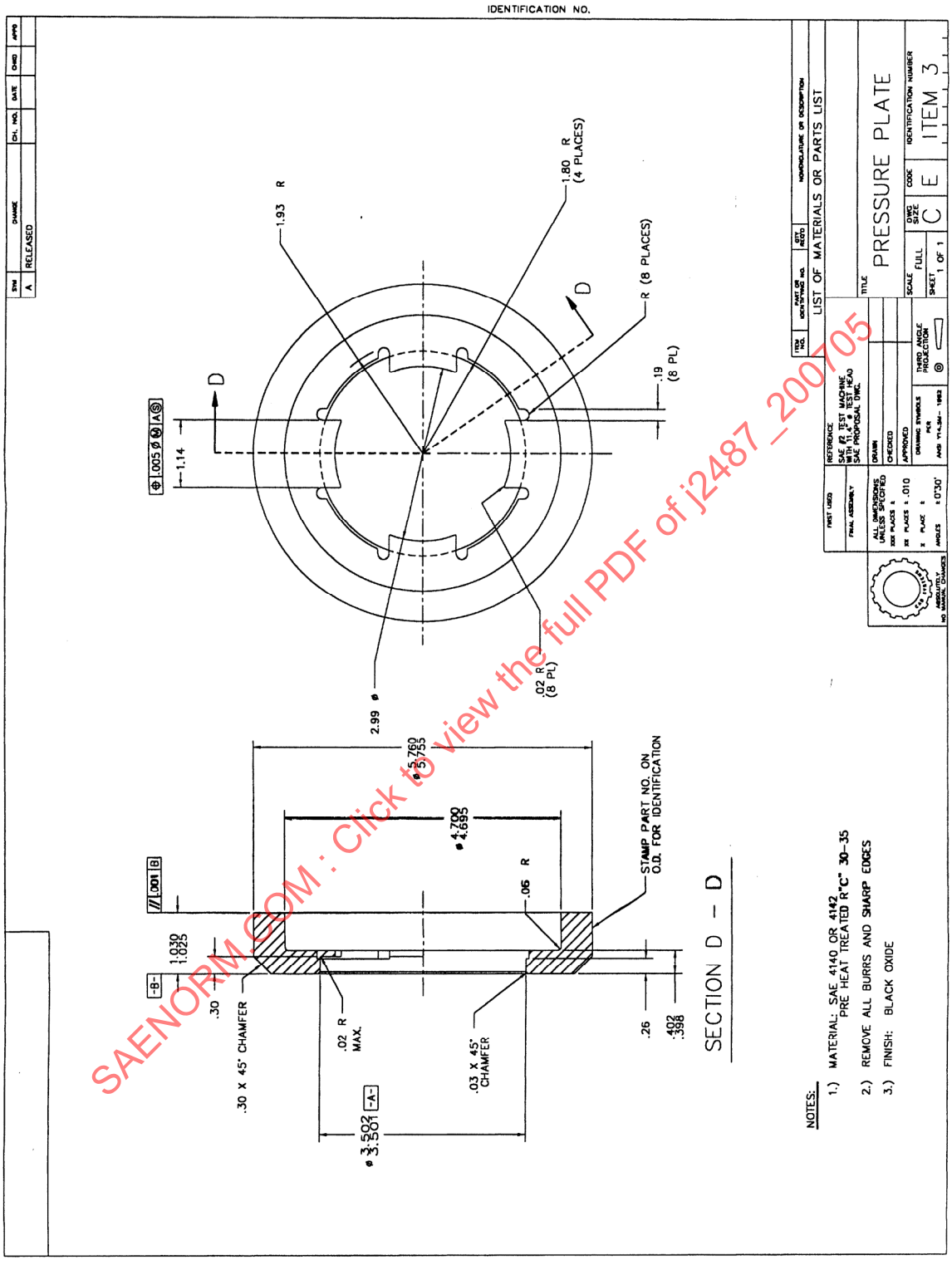

FIGURE A3 - ITEM 3 - PRESSURE PLATE

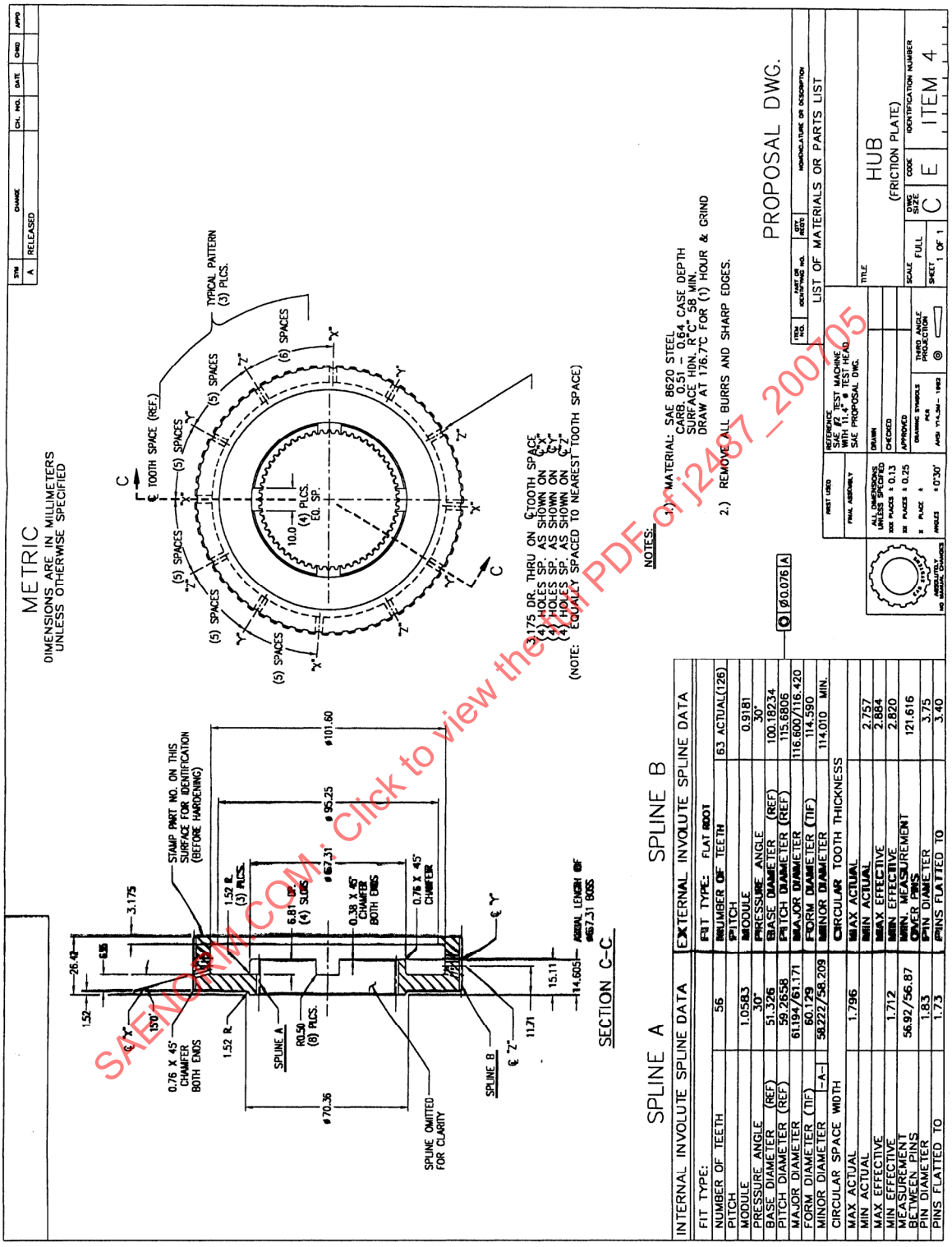

FIGURE A4 - ITEM 4 - FRICTION PLATE HUB

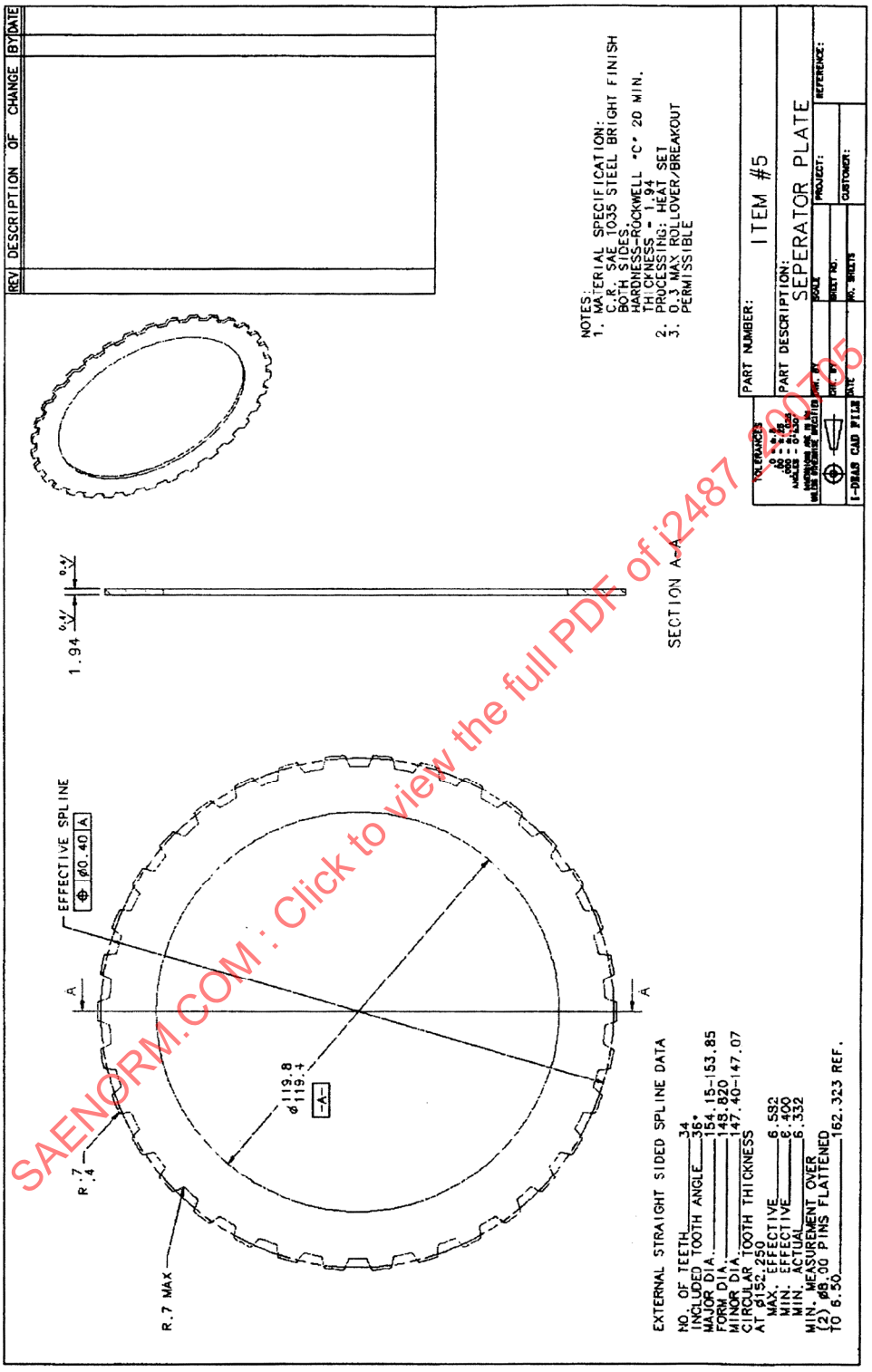

FIGURE A5 - ITEM 5 - SEPARATOR PLATE

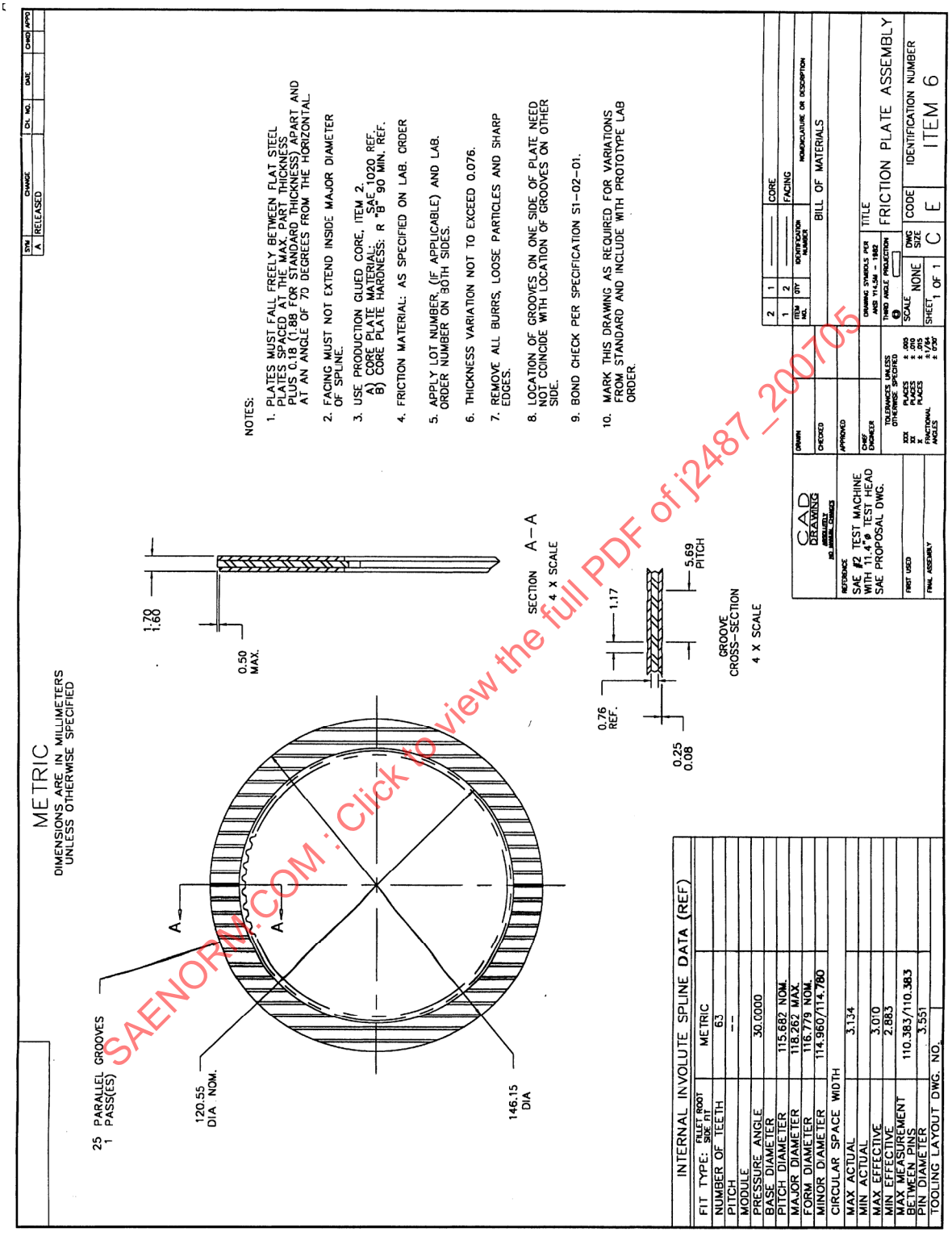

FIGURE A6 - ITEM 6 - FRICTION PLATE ASSEMBLY

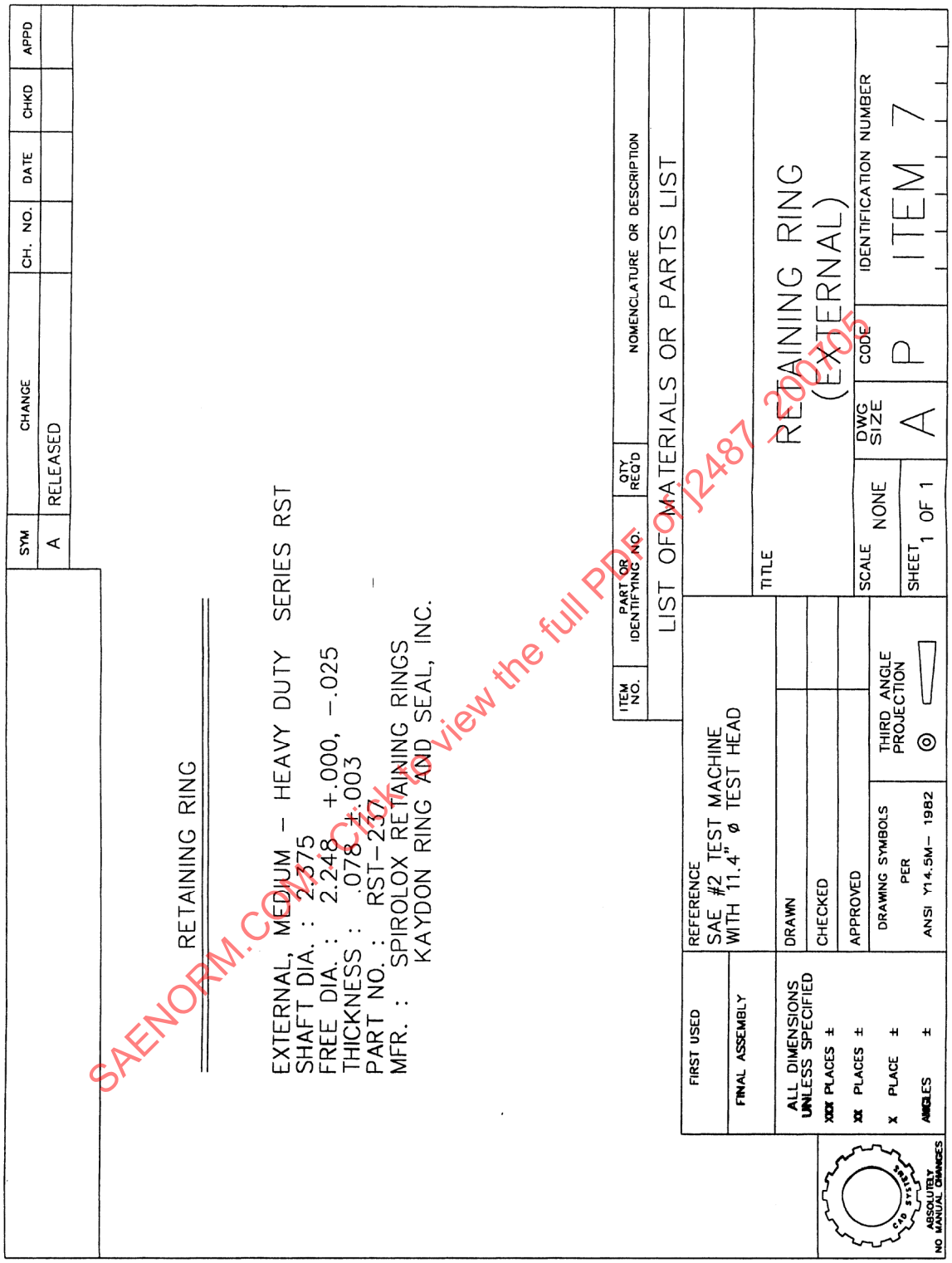

FIGURE A7 - ITEM 7 - RETAINING RING (EXTERNAL)

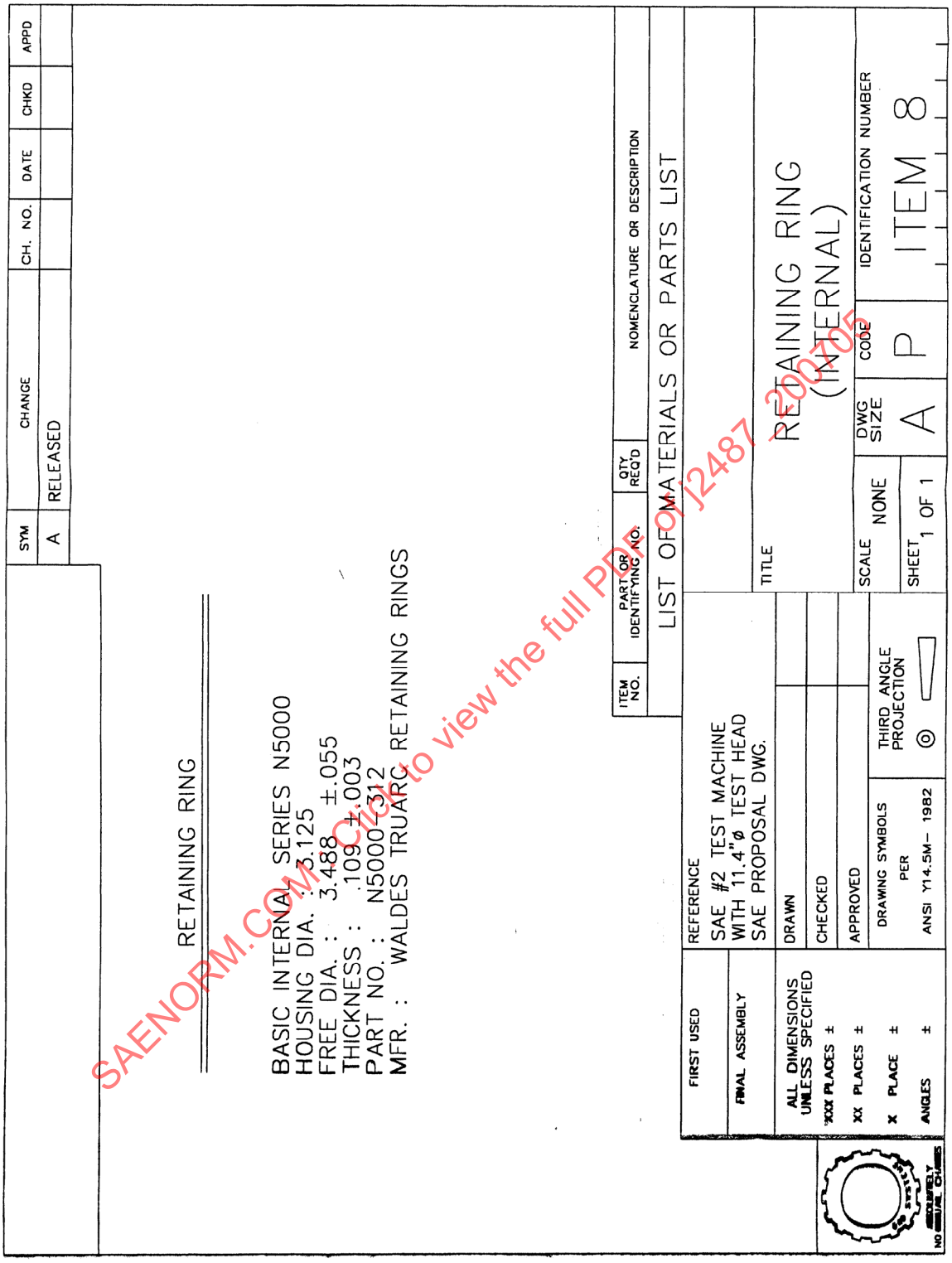

FIGURE A8 - ITEM 8 - RETAINING RING (INTERNAL)

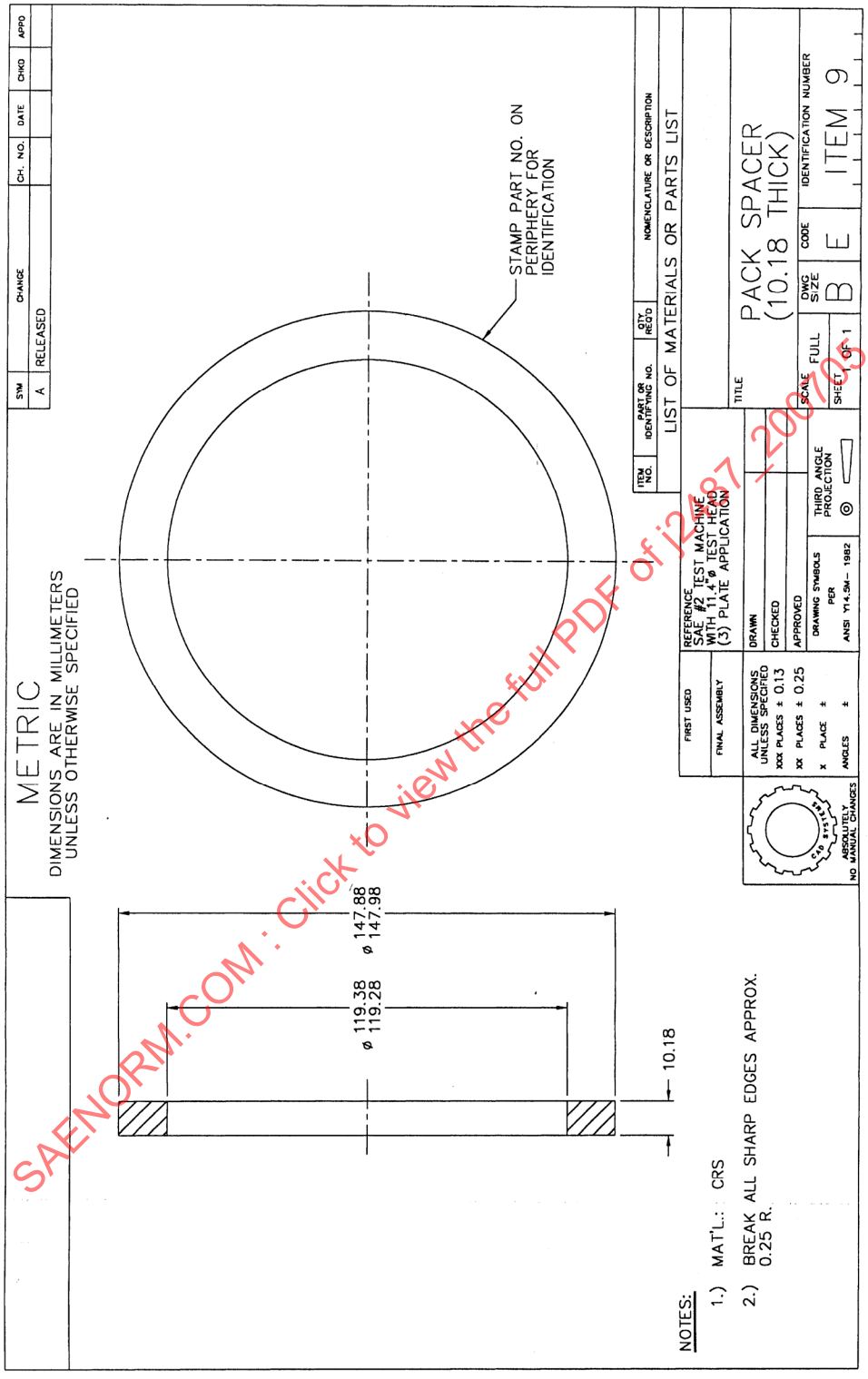

FIGURE A9 - ITEM 9 - 3 PLATE SPACER (10.18 THICK)

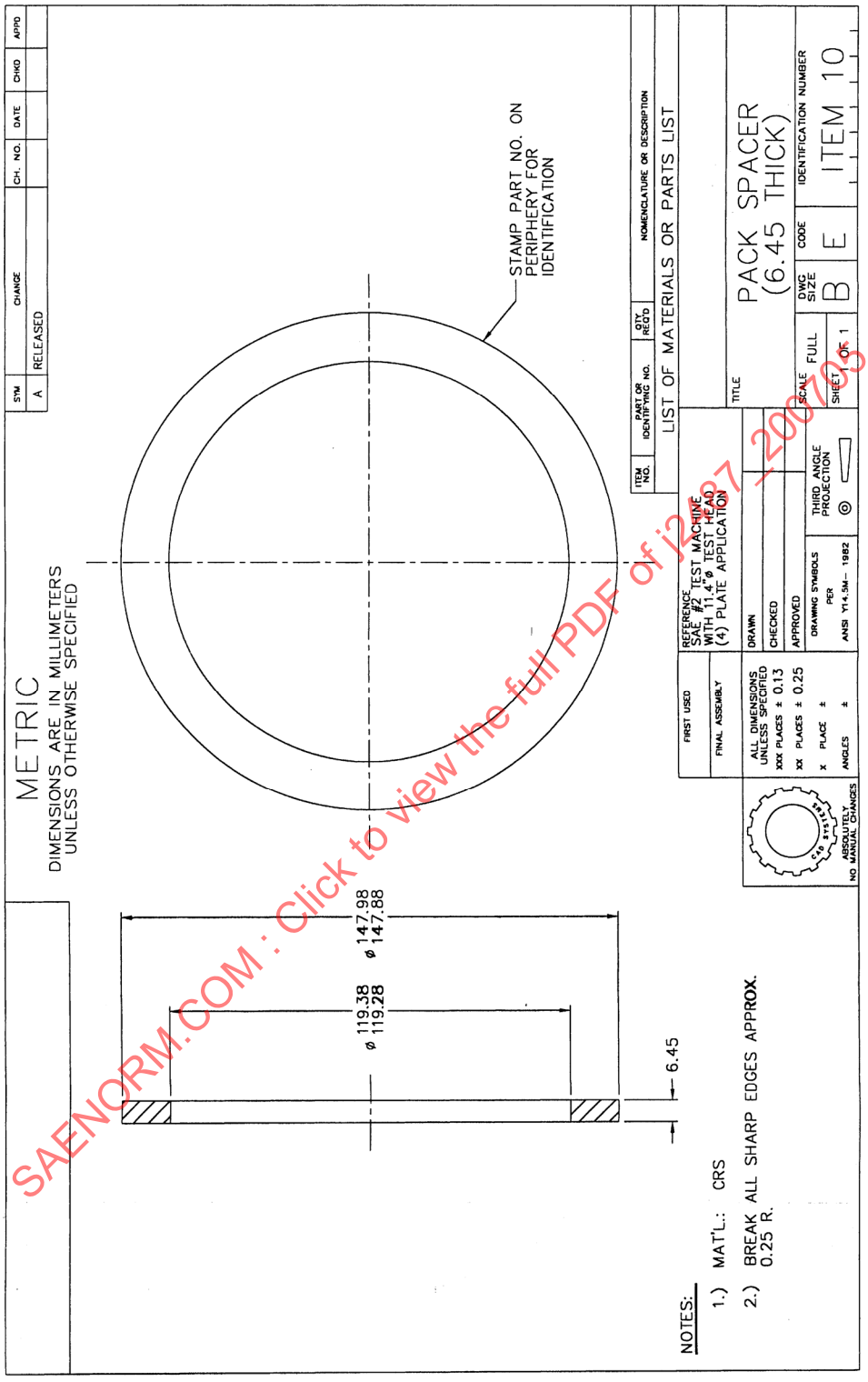

FIGURE A10 - ITEM 10 - 4 PLATE SPACER (6.45 THICK)

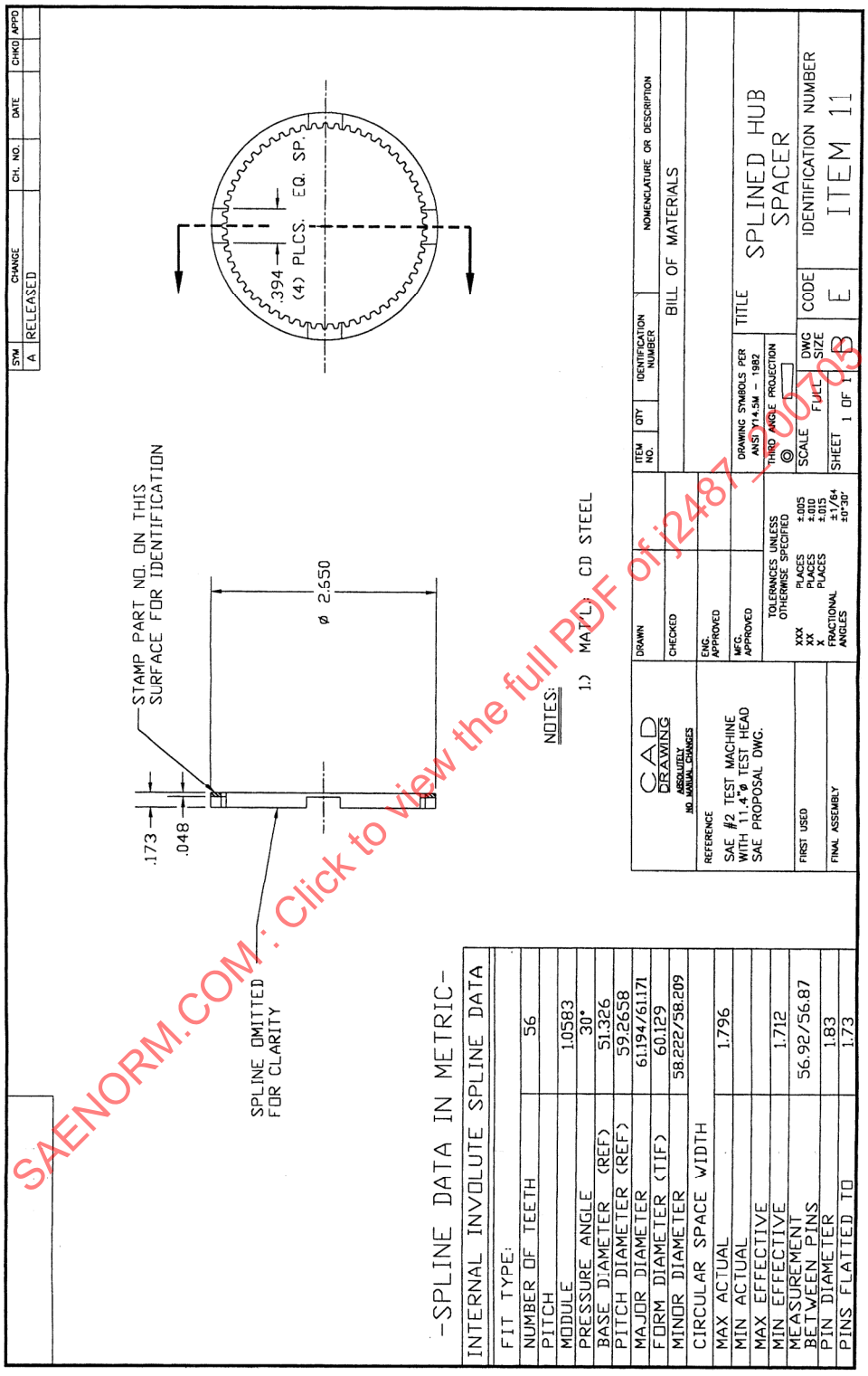

FIGURE A11 - ITEM 11 - SPLINED HUB SPACER

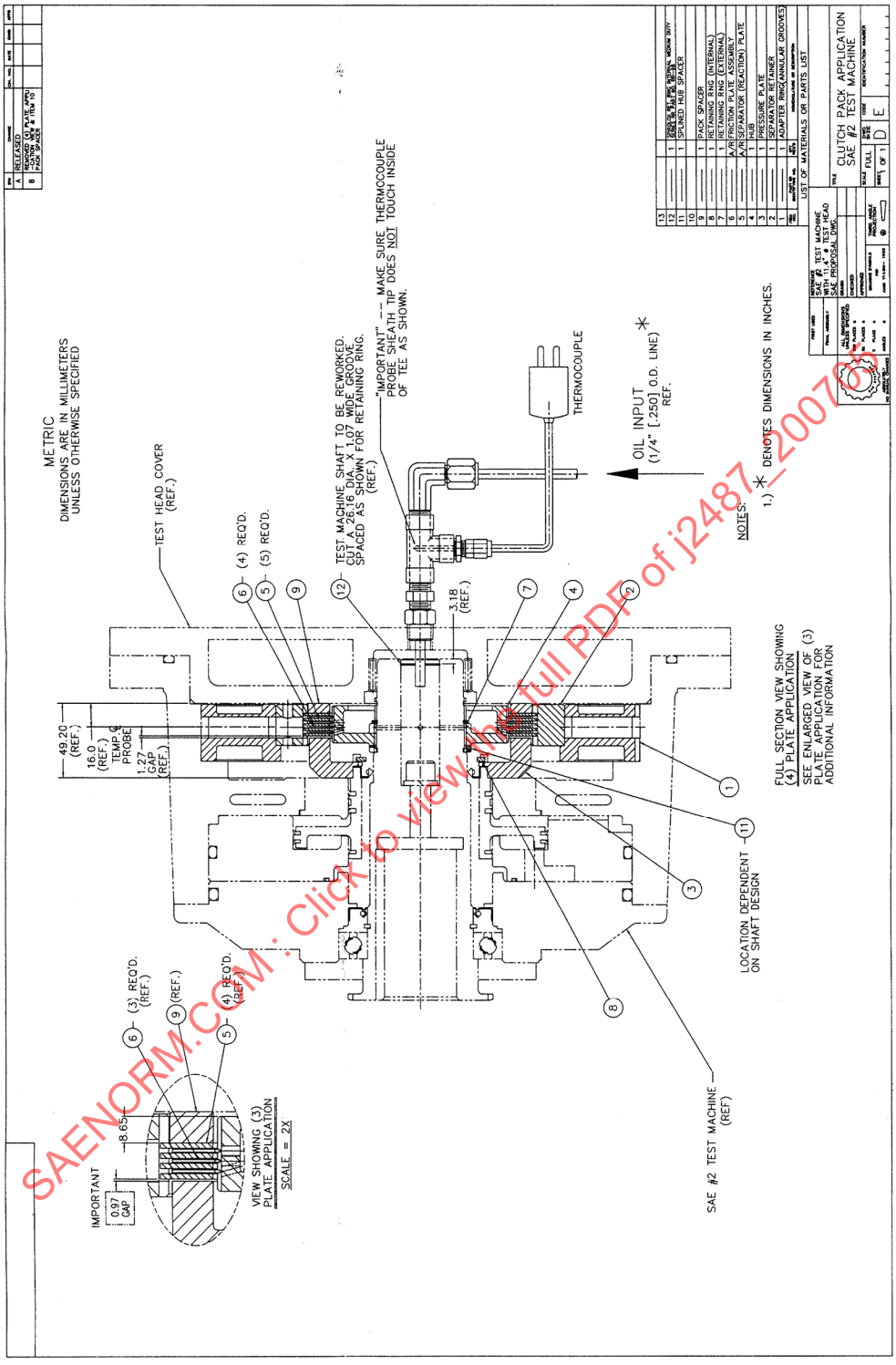

FIGURE A12A - ITEM 12 A - SPIRO-LOCK RETAINING RING
3 PLATE ASSEMBLY CROSS SECTION