CTN Test Report
89-002

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Engineering Drawing Transfer Test With Douglas Aircraft Company: MIL-D-28000 Class II (IGES)

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Contents

Preface

I acknowledge the following people for their cooperation during testing and contribution to this test report: Michael Gygi, Robert Mitchiner, and George Wong of Douglas Aircraft Company; Susan Sutherland, Alan Dragoo, Carol Lietz, William Schulenburg, Vincent Lespron, and Ruben Kreimer, of McDonnell Douglas Manufacturing & Engineering Systems Company; Kenneth Sivori of LLNL; and the CTN staff members.

This report does not endorse any product, process, or company.

Executive Summary

The DoD Computer-aided Acquisition and Logistic Support (CALS) Test Network (CTN) is conducting tests of the military standard for the Automated Interchange of Technical Information, MIL-STD-1840A (1840A) [OSDA88] and its companion suite of military specifications. The CTN is a DoD sponsored confederation of voluntary participants from industry and Government, managed jointly by a technical staff at Air Force Logistics Command (AFLC) and Lawrence Livermore National Laboratory (LLNL). The objective of the CTN tests is to demonstrate and evaluate the interchange and functional use of digital technical information between industry and government using the CALS Standards.

This test was a CTN Planned Test (CPT) [CTN89] with Douglas Aircraft Company (DAC). It was conducted at a DAC facility in Long Beach, California, February 7-9, 1989.

The objective of the CPT was to test the engineering drawing subset of Initial Graphics Exchange Specification (IGES) [NBS88] entities defined in the Military Specification for the Digital Representation for Communication of Product Data: IGES Application Subsets, MIL-D-28000 Amendment 1 (28000) [OSDD88]. Since DAC is preparing to accept data from a subcontractor in conjunction with its DoD C17 contract, the primary goal of this test was to demonstrate, test, and evaluate DAC's ability to interchange and use digital data in 1840A/28000 form. A secondary goal was to evaluate the CTN's 28000 Class II Reference Material utilized for the first time in this test and scheduled for use in subsequent tests of 28000.

The CTN Reference Material utilized during this test included drawing generation scripts, evaluation scripts, reference IGES files, and procedures to conduct both pre- and post-processor testing. The CTN Reference Drawings (N- entity and L-bracket) contained every IGES entity specified in the engineering drawing subset (Class II) of 28000.

The overall results were excellent. Douglas Aircraft Company used a McDonnell Douglas Unigraphics II (UGII) CAD system which performed well in both pre- and post-processing. UGII's IGES translators directly processed or mapped a respectable 94 percent of the IGES entities in the Class II subset of 28000. Another important observation was that DAC was able to both read and write 9-track tapes in accordance with 1840A.

On the basis of this test it is recommended that:

1) Unigraphics make minor modifications to its CAD drafting software and IGES processors to support more or all of the 28000 subsets. Unigraphics has already expressed the desire to do so.
2) The CTN technical staff suggest modifications to 1840A and 28000 as outlined in the conclusion.
3) The software to automate the reading and writing of 1840A tapes be completed by the CTN technical staff and distributed to industry and Government.

Table 1
Summary of MIL-STD-1840A Testing - Douglas Aircraft Company

Major Compliance Category	pass/fail
Pre-processing	
Ability to Write Transmission Envelope	
ANSI Level 3 Tape	Pass
MIL-STD-1840A Tape	Pass
Declaration Files	Part
Header Records	Part
Ability to Pre-process IGES	
Process to IGES Version 4.0	Pass
Process 28000 Class II Compliant Entities	Part
Post-processing	
Ability to Read Transmission Envelope	
ANSI Level 3 Tape	Pass
MIL-STD-1840A Tape	Pass
Declaration Files	Pass
Header Records	Pass
Ability to Post-process IGES	
Process to IGES Version 4.0	Pass
Process Entire 28000 Class II Subset	Part
Produce a Good Image	Part

pass = compliant in all respects
part = partial compliance, usable data
fail = noncompliant, unusable data

1 Introduction

The CALS Test Network (CTN) conducted a CTN Planned Test (CPT) of MIL-STD-1840A (1840A) and the MIL–D–28000 Class II (28000) specification with Douglas Aircraft Company (DAC) in Long Beach, CA, February 7-9, 1989. The CTN technical staff was interested in testing with DAC because the company is preparing to accept Initial Graphics Exchange Data (IGES) data from the Automated Design Center (ADC) in Torrance, California who is building the electronic development fixture for the C17 (DoD's new cargo plane) nose assembly. Under this contract, ADC plans to develop 3000 plus engineering drawings on a McDonnell Douglas Unigraphics II (UGII) CAD system and translate them to IGES for delivery to the DAC engineering department. For this reason, DAC is concerned with the ability of UGII to pre-process IGES, and in the case of redesigns, UGII's ability to post-process IGES. In keeping with DoD's new directive to use the CALS standards, DAC also wants to begin to understand UGII's conformance to 28000 and DAC's ability to read and write 1840A standard tapes.

2 Test Data and Procedures

2.1 Test Data

The data used during the DAC test was prepared by the CTN technical staff. The data conforms to the engineering drawing subset, Class II, of 28000 and is available to all CTN members in a document called the "CALS Test Network MIL-D-28000 Class II Reference Drawing Packet" [FARR89]. The packet contains the material needed to execute a test using CAD vendors' IGES processors. For the pre-processor test, the packet contains the test procedures and scripts to follow to generate the reference drawings on the CAD system. For the post-processor test, the packet contains test procedures, the reference drawings on a 9-track tape in IGES format to read into the CAD system, and scripts to follow to evaluate the resulting CAD model.

This packet also contains data to study 28000's parent document, the 1840A military specification. 1840A specifies the header records that must precede the data within the data files and the declaration files that must precede the data files on the 9-track tape. The "CTN MIL-D-28000 Class II Reference Drawing Packet" requests inclusion of this 1840A information on the tape during the pre-processor test and includes the header and declaration information on the reference tape for the post-processor test.

The two reference drawings referred to are the N-entity and the L-bracket drawings. Plots of these drawings are marked Exhibits 1 and 2 in Appendix A. Together the N-entity and the L-bracket reference drawings contain all of the IGES entities identified in the Class II subset of 28000. Having this test suite that incorporates all of the Class II entities allows the CTN technical staff to: (1) demonstrate industry's and Government's use of these IGES entities, and (2) evaluate the Class II subset and 28000 specification.

2.2 Test Procedures

The specific DAC test procedures were as follows:

1. DAC created the N-entity and the L-bracket drawings on the Unigraphics II Version 6.0 CAD system by following the generation scripts. The CTN technical representative recorded any deviations taken from the script. The Unigraphics II software was operating on a MicroVAX II with 16 MB RAM memory, 3 hard disks with 300 MB total memory, and a McDonnell Douglas D-135 graphics terminal.

2. DAC pre-processed the drawings into IGES formats, recorded the entity mapping switches, and recorded any processing errors the system reported.

3. DAC hand edited the 1840A header records into the IGES files, created declaration files for the IGES files, and copied all files to a 9-track tape with the 1840A specified formats.

4. DAC hand delivered the 9-track tape to the CTN technical representative who conducted pre-processor analysis. Pre-processor test evaluation involved analyzing the files with the CTN 1840A Tape Evaluation Tool, the IGES Data Analysis Parser/ Verify and View Software, and the Glatz Associates IGES Model Testing System.

5. DAC accepted a 9-track tape from the CTN technical representative containing the N-entity and the L–bracket reference drawings in fully compliant 1840A and 28000 Class II format.

6. DAC loaded the files onto the MicroVAX II system, read the declaration files, and hand edited the 1840A header records from the IGES files.

7. DAC post-processed the IGES files into the UGII native CAD format and displayed the graphics on the terminal. The CTN technical representative recorded the entity mapping switch settings and all errors the post-processor reported.

8. DAC answered questions listed in the evaluation scripts about the post-processed models and plotted the graphics.

9. DAC hand delivered the plots and the completed evaluation scripts to the CTN technical representative who conducted the post-processor analysis which involved comparing the expected results to the actual.

3 Test Results

3.1 Transmission Envelope

Overall, DAC was able to both read and write tapes in accordance with 1840A and 28000, but experienced some difficulty. These difficulties, which regard the required 1840A declaration files, 1840A header fields, and 28000 start section records, are discussed in the following sections.

3.1.1 MIL-STD-1840A Declaration Files and Header Fields

While writing the 1840A declaration files and header fields, DAC had some difficulty and questions with 1840A. At first, DAC forgot to insert the record identifiers before the record information. This reconfirms the need for automated tape writing tools which prompt the user for the record information and place it properly after the record identifier. The CTN technical staff has these tools in development, and they will soon be available to all CTN members. Also, DAC misspelled two of the record identifiers. This again suggests a need for automated tools. Next, DAC did not have access to MIL-STD-804 [AEC66] to properly furnish Record 1 of the IGES file header fields. The CTN recognizes that all standards and specifications must be easily available without, for example, two months ordering/shipping time. This reconfirms the need for up-to-date copies of all of the standards to be available electronically on the CALS bulletin board and possibly on the CTN Information Exchange (Info-X) [GARN89]. Finally, DAC had questions regarding what to enter for product data in Record 4 of the IGES file header fields. The CTN technical staff suggests adding a sentence to 1840A to address this issue.

Regarding the reading of the 1840A tapes, DAC was able to read all 1840A information, but had to strip the IGES file headers by hand. This too suggests a need for an automated tool which will strip headers and properly prepare the IGES files.

3.1.2 MIL-D-28000 Class II Start Section

MIL-D-28000 Class II specifies some of the information to be given in the start section of the IGES file. One piece of information is a "Statement of conformance to the application subset and date". The word "date" was confusing to DAC. Does it refer to the release date of the specification? The CTN technical staff recommends rewording the specification to clear up this confusion. Also, 28000 asks for the "Data organization method with contents of each level". This too was confusing to DAC. The CTN technical staff recommends adding an example to help explain what DoD is requesting. All recommended rewordings of both 28000 and 1840A are detailed in the conclusion of this report.

3.2 Processing of IGES/MIL-D-28000 Class II Data

Table 2 summarizes the IGES entities that were both pre- and post-processed by this particular UGII system at DAC. The entities listed in Table 2 are all the entities identified in 28000 Class II; all are tested in the CTN's Reference Drawings. The results and comments about the processing refer to what the CTN technical representative discovered while testing with the N-entity and the L-bracket Reference Drawings. Keep in mind that the results from other testing will vary depending upon the depth of entity testing, upon the CAD hardware/software configuration, and upon the entity mapping switch settings. In most cases, the results concurred with UGII's published "IGES User Guide"[MCDD88] which in general was quite comprehensive and useful, but did reveal the entity mapping in more detail. The results also pinpointed some errors and misprints in the user guide.

Referring to the table to explain the terminology, "yes" means that the processed entity maintained its intent and functionality. For example: in the first record, the first "yes" means that a circular arc-shaped figure pre-processed to a circular Arc Entity (100) in the IGES file; the second "yes" means that the Circular Arc Entity (100) in the IGES file post-processed to a circular arc-shaped figure on the CAD system. "Map" means that the intended information was transferred, but not by this particular entity. For example: in the second record, the grouping of the point, line, arc, and spline pre-processed not into the Composite Curve Entity (102), but mapped instead into a similar entity, the Group without Back Pointers (402 Form 7). "Part" means that the entity was able to transfer part of the information and/or maintain partial intent or functionality. For example: in the second record, the Composite Curve Entity (composed of a point, line, arc, and spline) was post-processed by UGII into a group containing the line, arc, and spline, but not the point. "No" means that the information contained in the entity was not transferred by the processors. The slash means that two different results occurred.

The numbers following the "part", "map", and "no" entries refer to the explanation about the transfer or mapping listed in Appendix B. The explanations refer to the results uncovered by the N-entity and the L-bracket Reference Drawings. Refer to the plots of the N-entity and L-bracket drawings marked Exhibits 1-6 in Appendix A to help better understand the comments.

Exhibit 1 - CTN N-entity Reference Drawing
Exhibit 2 - CTN L-bracket Reference Drawing
Exhibit 3 - DAC N-entity Drawing Before Pre-processing
Exhibit 4 - DAC L-bracket Drawing Before Pre-processing
Exhibit 5 - DAC N-entity Drawing After Post-processing
Exhibit 6 - DAC L-bracket Drawing After Post-Processing

Table 2
The Ability of UGII to Pre- and Post-process The MIL-D-28000 Class II Entities

Entity Number	Form Number	Entity Name	Pre-process	Post-process
100		Circular Arc	yes	yes
102		Composite Curve	yes/map1	part2
104	0	Conic Arc - General	map3	yes
104	1	Conic Arc - Ellipse	yes	yes
104	2	Conic Arc - Hyperbola	yes	yes
104	3	Conic Arc - Parabola	yes	yes
106	11	Linear Planar Curve	map4	yes
106	12	Coordinate Triples	map5	yes
106	20	Centerline Thru Points	yes/map6	yes
106	21	Centerline Thru Centers	map7	yes
106	31	Section Form 31	yes	yes
106	32	Section Form 32	yes	yes
106	33	Section Form 33	yes	yes
106	34	Section Form 34	yes	yes
106	35	Section Form 35	yes	yes
106	36	Section Form 36	yes	yes
106	37	Section Form 37	yes	yes
106	38	Section Form 38	yes	yes
106	40	Witness Line	yes	yes
106	63	Simple Closed Area	yes/map8	yes
108	0	Unbounded Plane	no9	yes
108	1	Bounded Plane	yes	yes
110		Line	yes	yes
112		Parametric Spline Curve	yes	yes
114		Parametric Spline Surface	yes	yes
116		Point	yes	yes
118	0	Ruled Surface - Arc Length	map10	no11
118	1	Ruled Surface - Parametric	yes	yes
120		Surface of Revolution	yes	yes
122		Tabulated Cylinder	yes	yes
124	0	Transformation Matrix D = 1	yes	yes
124	1	Transformation Matrix D = -1	no12	yes
126	0	Rational B-Spline Curve	yes	yes

Entity Number	Form Number	Entity Name	Pre-process	Post-process
128	0	Rational B-Spline Surface	yes	yes
128	2	RBS Right Circular Cylinder	map13	yes
128	3	RBS Cone	map14	yes
128	4	RBS Sphere	map15	yes
128	5	RBS Torus	map16	yes
128	9	RBS General Quadratic	map17	yes
130		Offset Curve	map18	part 19
140		Offset Surface	map20	part 21
142		Curve on Parametric Surface	yes	yes
144		Trimmed Parametric Surface	yes	part 22
202		Angular Dimension	yes	yes
206		Diameter Dimension	yes	yes
210		General Label	yes	yes
212	0	General Note - Simple	part23	part24
212	1	Note - Dual Stack	map25	yes
212	2	Note - Imbedded Font Change	map26	part27
212	3	Note - Superscript	map28	yes
212	4	Note - Subscript	map29	yes
212	5	Note - Super/Subscript	map30	yes
212	6	Note - Multi Stack Left Just	map31	yes
212	7	Note - Multi Stack Cent Just	map32	yes
212	8	Note - Multi Stack Right Just	map33	yes
212	100	Note - Simple Fraction	map34	yes
212	101	Note - Dual Stack Fraction	map35	yes
212	102	Note - Font/Double Fraction	map/prt36	part37
212	105	Note - Super/Sub Fraction	map38	yes
214	1	Leader - Wedge	part39	map40
214	2	Leader - Triangle	yes	yes
214	3	Leader - Filled Triangle	map41	map42
214	4	Leader - No Arrow	map43	yes
214	5	Leader - Circle	yes	yes
214	6	Leader - Filled Circle	map44	map45
214	7	Leader - Rectangle	map46	map47
214	8	Leader - Filled Rectangle	map48	map49
214	9	Leader - Slash	yes	yes
214	10	Leader - Integral Sign	map50	map51
214	11	Leader - Open Triangle	map52	map53
216		Linear Dimension	yes	yes
218		Ordinate Dimension	yes	yes

Entity Number	Form Number	Entity Name	Pre-process	Post-process
220		Point Dimension	map54	yes
222		Radius Dimension	yes	yes
228	0	Symbol - General	yes/map55	part56
228	1	Symbol - Datum Feature	map57	yes
228	2	Symbol - Datum Target	map58	yes
228	3	Symbol - Feature Control	map59	part60
230		Sectioned Area	part61	yes
304	1	Line Font - repeating subfig	map62	map63
304	2	Line Font - repeat vis/bnk	map64	map65
308		Subfigure Definition	map66	yes
314		Color Definition	map67	yes
402	3	Views Visible	no68	yes
402	4	Views Visible, Color, Line Ft	no69	no70
402	15	Ordered Group w/o Back Pointer	map71	yes
404		Drawing	yes/prt72	yes
406	1	Definition Levels	no73	no74
406	3	Level Function	no75	yes
406	5	Line Widening	no76	no77
406	15	Name	yes	yes
406	16	Drawing Siz	yes	yes
406	17	Drawing Units	yes	yes
408		Subfigure Instance	map78	yes
410		View	yes	yes

Totals:	Of 95 Entities and Forms	Pre-processing*	Post-processing
		yes = 44	yes = 73
		map = 45	map = 9
		part = 5	part = 9
		no = 7	no = 4

*Multiple results were recorded on six entities

3.2.1 General Comments on Pre-processing

Exhibit 3 and Exhibit 4 are the N-entity and the L-bracket CAD models respectively as drafted by DAC on the UGII CAD system. On the N-entity drawing, DAC was able to draft most of the desired entities well, although DAC substituted or approximated some entities when UGII did not support them. Exhibit 1 is the expected appearance of the N-entity drawing; note how closely Exhibit 3 resembles Exhibit 1. Regarding the L-bracket drawing, DAC was able to follow the CTN's generation script quite closely and quickly to generate this four-viewed engineering drawing containing both model and drawing entities. Exhibit 2 is the expected appearance of the L-bracket drawing; note how closely Exhibit 4 resembles Exhibit 2.

Upon analyzing the pre-processed IGES files of the N-entity and the L-bracket drawings, the CTN technical staff had one comment about UGII's pre-processing. This problem exists on top of those commented upon in Appendix B.

1. In the Global Section of the IGES files, the Global Parameters Number 17 (Line Width) and 20 (Maximum Coordinate Value) were both defaulted by UGII. MIL-D-28000 Class II requires that both these parameters be specified. UGII will address this issue in a future software release.

3.2.2 General Comments on Post-processing

Exhibit 5 is the post-processed plot of the N-entity reference drawing. Exhibit 6 is the L-bracket drawing. Compare these plots to Exhibit 1 and 2 respectively and again note the close resemblance. UGII was able to post-process both drawings with virtually no problems. Only a few entities were incomplete or missing as discussed in Appendix B. The following are two distinctive yet necessary procedures that DAC and the CTN technical representative had to follow before being able to adequately work with the post-processed drawings.

1. We had to execute a command to ask the part to change from 2D to 3D before being able to see the full three dimensionality.

2. We had to make the views reference views before we could select all the entities on the screen. We had to follow this procedure because UGII translated in active views (Top, Right, etc...) on top of an active view (the Drawing); UGII considers the Drawing to be a view.

4 Conclusions and Recommendations

The N-entity and the L-bracket drawings contained many entities for testing purposes, some complicated and rarely used, yet Douglas Aircraft's McDonnell Douglas Unigraphics II CAD system handled both pre- and post-processing these CTN drawings with grace. As a result of the testing, the CALS Test Network technical staff recommends that:

1. Unigraphics make minor modifications to its CAD drafting software and IGES processor to support more or all of the 28000 subset. Unigraphics has already expressed the desire to do so.

2. The CTN technical staff complete and distribute the software to automate the reading and writing of 1840A tapes to industry and Government.

3. All CALS Standards be available electronically on the CALS bulletin board and the CTN Information Exchange to hasten the Standards' delivery and utilization time.

4. The CTN technical staff prepare wording and subset changes to 1840A and 28000 as follows:

   a. MIL-STD-1840A, NOTICE 1, 20 December 1988, Page 20, Section 5.1.4.3. IGES data file header records: Add to the bottom of the RECORD 4 description, "For product data, enter the character string, NONE."

   b. MIL-D-28000, Amendment 1, 20 December 1988, Page 11, Section 3.2.2.2. ANSI Y14.26M entity subset specification: Add the IGES entity Group without Back Pointers (402 Form 7) to the engineering drawing subset (Class II).

   c. MIL-D-28000, Amendment 1, 20 December 1988, Page 15, Section 3.2.2.4.1. Start section: Modify the item a. to read, "a. Statement of conformance to this application subset and the release date of the specification."

   d. MIL-D-28000, Amendment 1, 20 December 1988, Page 15, Section 3.2.2.4.1. Start section: Modify the item d. to read, "d. Performing organization, contract number, and date of IGES file pre-processing."

   e. MIL-D-28000, Amendment 1, 20 December 1988, Page 15, Section 3.2.2.4.1. Start section: Modify the item f. to read,

      "f. Data organization method with contents of each level, for example:

Level	Description
1	model entities
201	dimensions
202	crosshatching"

f. MIL-D-28000, Amendment 1, 20 December 1988, Page 14, Section 3.2.2.3. Entity construction: Add, "At least one drawing entity is required in each IGES file." as the third sentence of the 404 Drawing paragraph.

Appendix A - Exhibits

Exhibits 1 through 6 follow this page. The list that follows numbers and describes the exhibits.

Exhibit 1 - CTN N-entity Reference Drawing
Exhibit 2 - CTN L-bracket Reverence Drawing
Exhibit 3 - DAC N-entity Drawing Before Pre-Processing
Exhibit 4 - DAC L bracket Drawing Before Pre-Processing
Exhibit 5 - DAC N-entity Drawing After Post-Processing
Exhibit 6 - DAC L-bracket Drawing After Post-Processing

Exhibit 1 - CTN N-entity Reference Drawing

CIRCULAR ARC (100)	COMPOSITE CURVE (102)	CONIC ARC - GENERAL (104 FORM 0)	CONIC ARC - ELLIPSE (104 FORM 1)	CONIC ARC - HYPERBOLA (104 FORM 2)	CONIC ARC - PARABOLA (104 FORM 3)	LINEAR PLANAR CURVE (106 FORM 11)	COORDINATE TRIPLES (106 FORM 12)	CENTERLINE THRU POINTS (106 FORM 20)	CENTERLINE THRU CENTERS (106 FORM 21)
SECTION 31 (106 FORM 31)	SECTION 32 (106 FORM 32)	SECTION 33 (106 FORM 33)	SECTION 34 (106 FORM 34)	SECTION 35 (106 FORM 35)	SECTION 36 (106 FORM 36)	SECTION 37 (106 FORM 37)	SECTION 38 (106 FORM 38)	A 1.000 WITNESS LINE (106 FORM 40)	SIMPLE CLOSED AREA (106 FORM 63)
UNBOUNDED PLANE (108 FORM 0)	BOUNDED PLANE (108 FORM 1)	LINE (110)	PARAMETRIC SPLINE CURVE (112)	PARAMETRIC SPLINE SURFACE (114)	POINT (116)	RULED SURFACE - ARC LENGTH (118 FORM 0)	RULED SURFACE - PARAMETRIC (118 FORM 1)	SURFACE OF REVOLUTION (120)	TABULATED CYLINDER (122)
TRANSFORMATION MATRIX D=I (124 FORM 0)	TRANSFORMATION MATRIX D=-I (124 FORM 1)	RATIONAL B-SPLINE CURVE (126 FORM 0)	RATIONAL B-SPLINE SURFACE (128 FORM 0)	RBS RIGHT CIRC CYLINDER (128 FORM 2)	RBS CONE (128 FORM 3)	RBS SPHERE (128 FORM 4)	RBS TORUS (128 FORM 5)	RBS GENERAL QUADRATIC (128 FORM 9)	OFFSET CURVE (130)
OFFSET SURFACE (140)	CURVE ON PARAMETRIC SURFACE (142)	TRIMMED PARAMETRIC SURFACE (144)	45.00° ANGULAR DIMENSION (202)	Ø.500 DIAMETER DIMENSION (206)	LABEL GENERAL LABEL (210)	SIMPLE SIMPLE GENERAL NOTE - SIMPLE (212 FORM 0)	DUAL STACK NOTE - DUAL STACK (212 FORM 1)	IM+a≥DED NOTE - IMBEDDED FONT CHANGE (212 FORM 2)	S SUPER NOTE - SUPERSCRIPT (212 FORM 3)
S SUB NOTE - SUBSCRIPT (212 FORM 4)	S SUPER SUB NOTE - SUPER/SUB SCRIPT (212 FORM 5)	M STACK LEFT NOTE - MULTI STACK LEFT JUST (212 FORM 6)	M STACK CENTER NOTE - MULTI STACK CENT JUST (212 FORM 7)	M STACK RIGHT NOTE - MULTI STACK RIGHT JUST (212 FORM 8)	S FRAC TION NOTE - SIMPLE FRACTION (212 FORM 100)	DUAL TO P STACK BOT TOM NOTE - DUAL STACK FRACTION (212 FORM 101)	IM BED DED ± FR ACT ION NOTE - FONT/DOUBLE FRACTION (212 FORM 102)	T O P FR SUP SUB BO TT OM NOTE - SUPER/SUB FRACTION (212 FORM 105)	LEADER - WEDGE (214 FORM 1)
LEADER - TRIANGLE (214 FORM 2)	LEADER - FILLED TRIANGLE (214 FORM 3)	LEADER - NO ARROW (214 FORM 4)	LEADER - CIRCLE (214 FORM 5)	LEADER - FILLED CIRCLE (212 FORM 6)	LEADER - RECTANGLE (214 FORM 7)	LEADER - FILLED RECTANGLE (214 FORM 8)	LEADER - SLASH (214 FORM 9)	LEADER - INTEGRAL SIGN (214 FORM 10)	LEADER - OPEN TRIANGLE (214 FORM 11)
1.000 LINEAR DIMENSION (216)	.000 .750 ORDINATE DIMENSION (218)	.000 POINT DIMENSION (220)	R .500 RADIUS DIMENSION (222)	AB SYMBOL - GENERAL (228 FORM 0)	-C- SYMBOL - DATUM FEATURE (228 FORM 1)	A2 SYMBOL - DATUM TARGET (228 FORM 2)	⊥ .02 SYMBOL - FEATURE CONTROL (228 FORM 3)	SECTIONED AREA (230)	CALS TEST NETWORK MIL-D-28000 CLASS II REFERENCE DRAWING N-ENTITY

Exhibit 2 - CTN L-bracket Reference Drawing

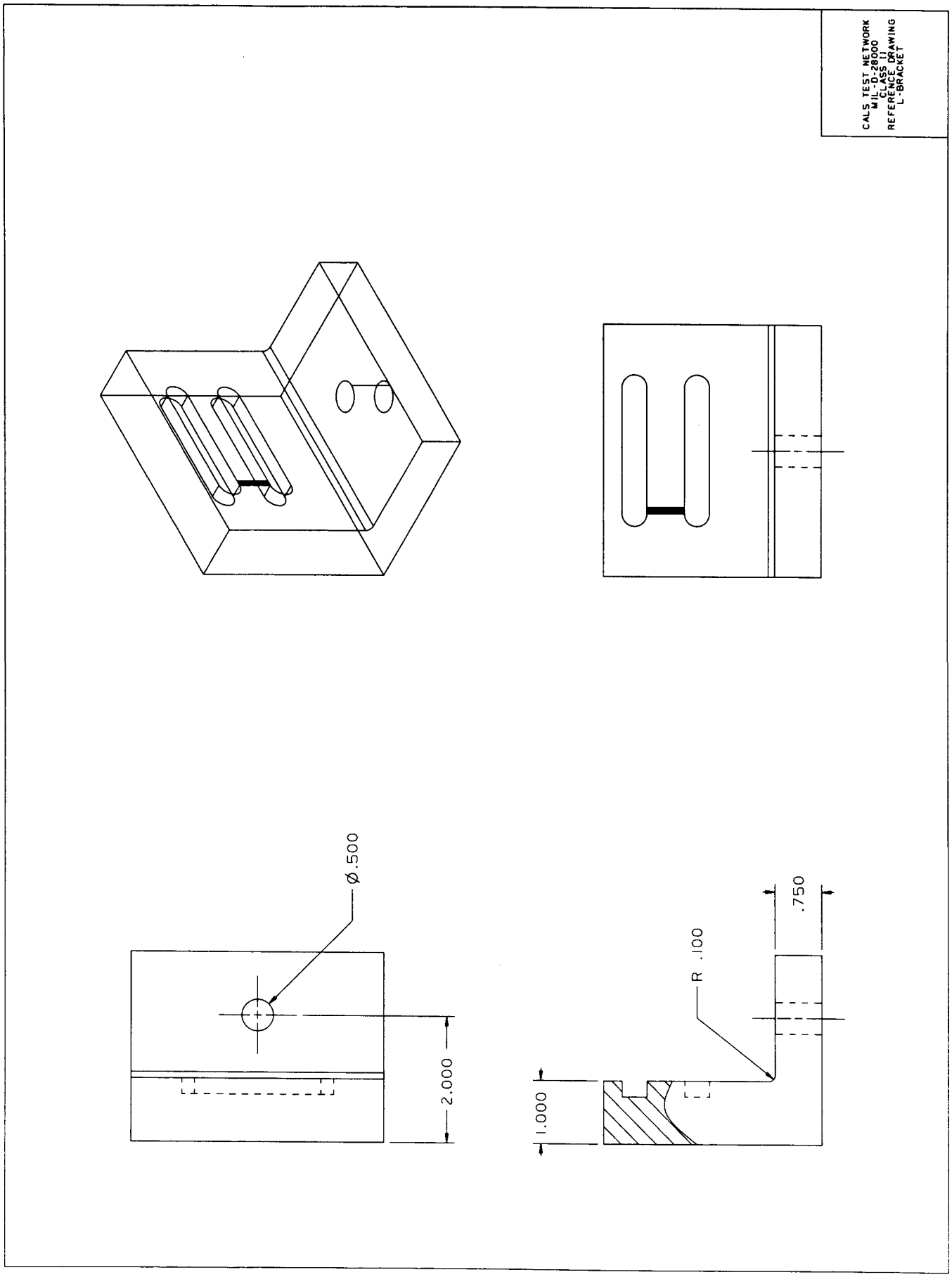


Exhibit 3 - DAC N-entity Drawing Before Pre-processing

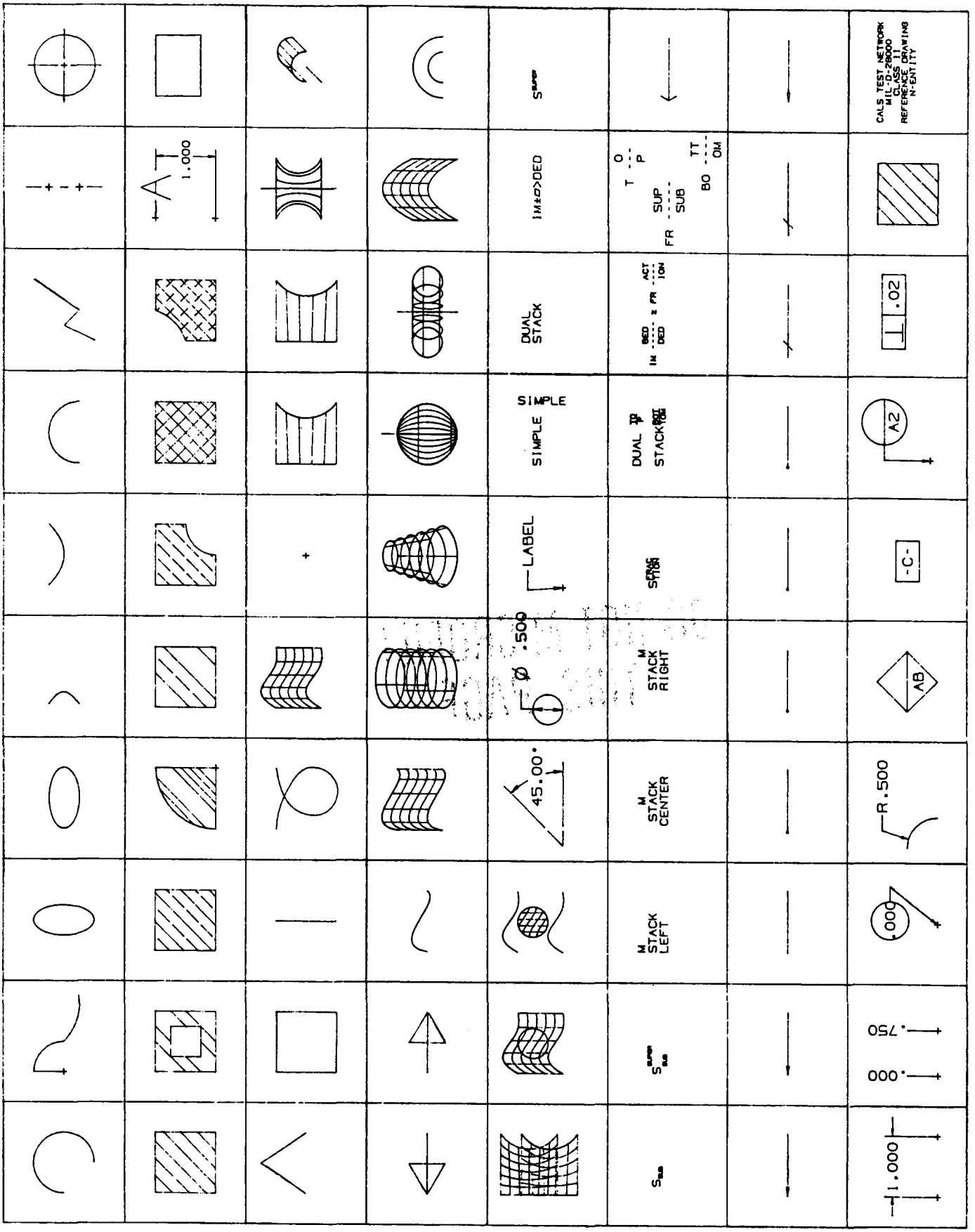


Exhibit 4 - DAC L-bracket Drawing Before Pre-processing

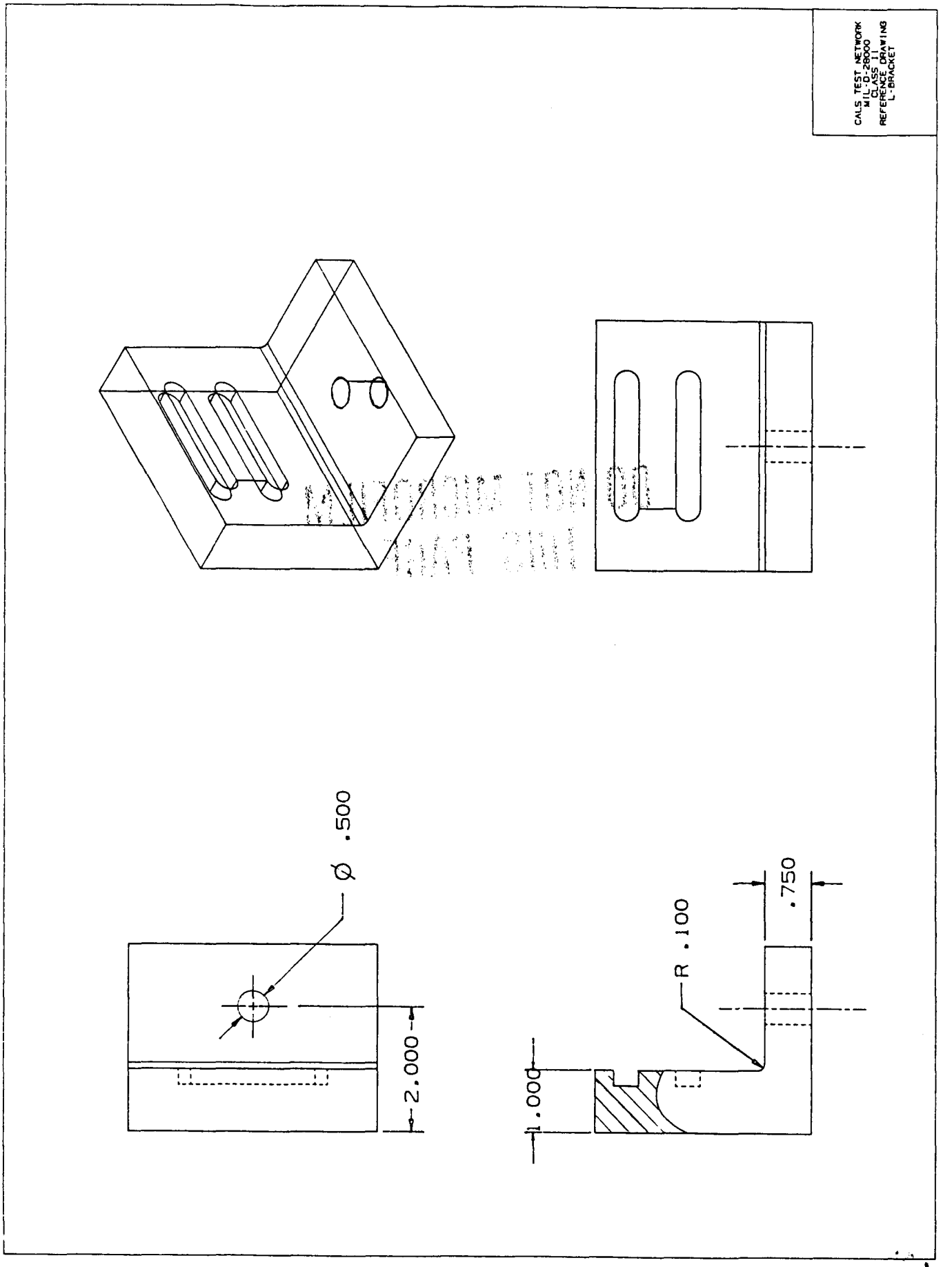


Exhibit 5 - DAC N-entity Drawing After Post-processing

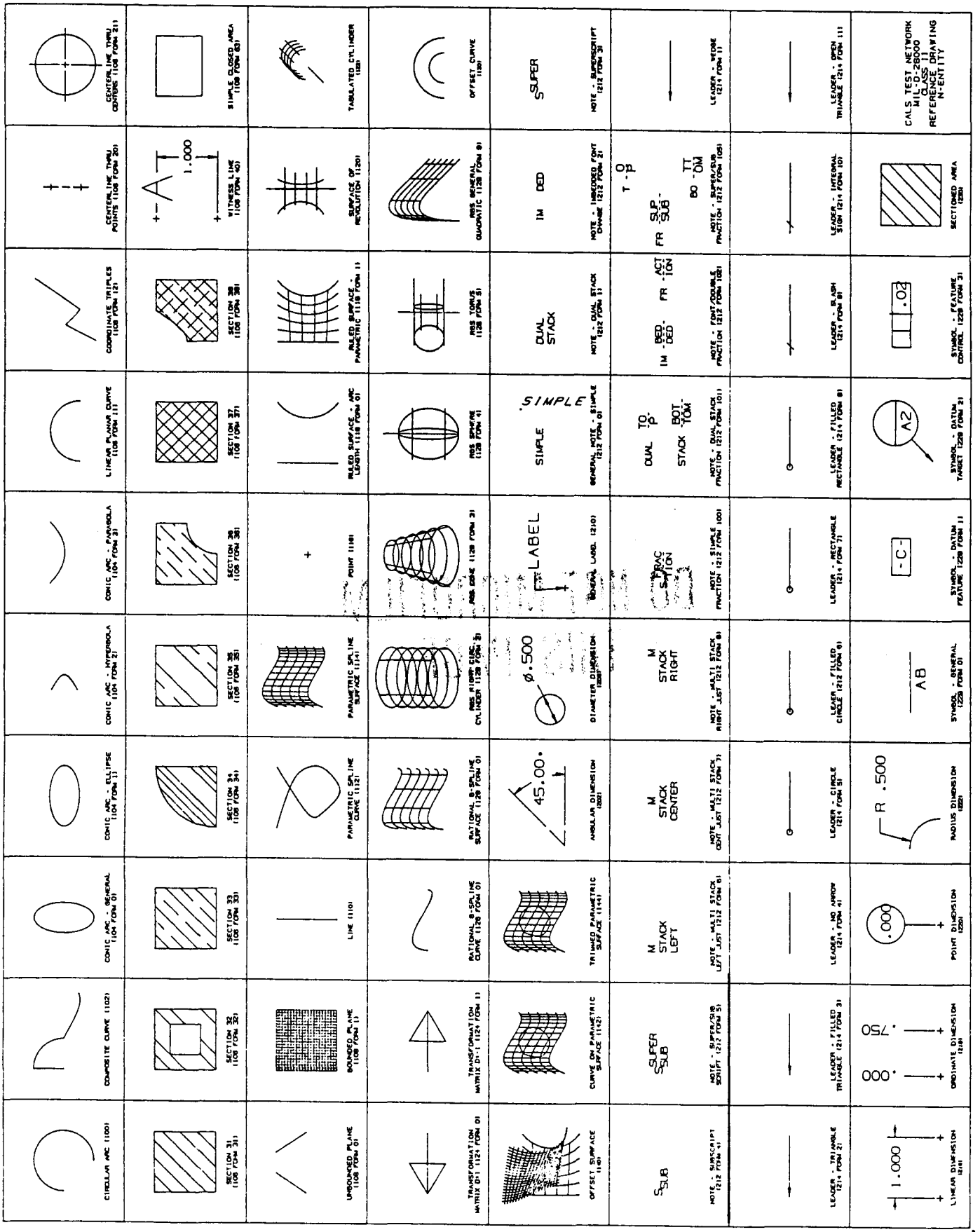
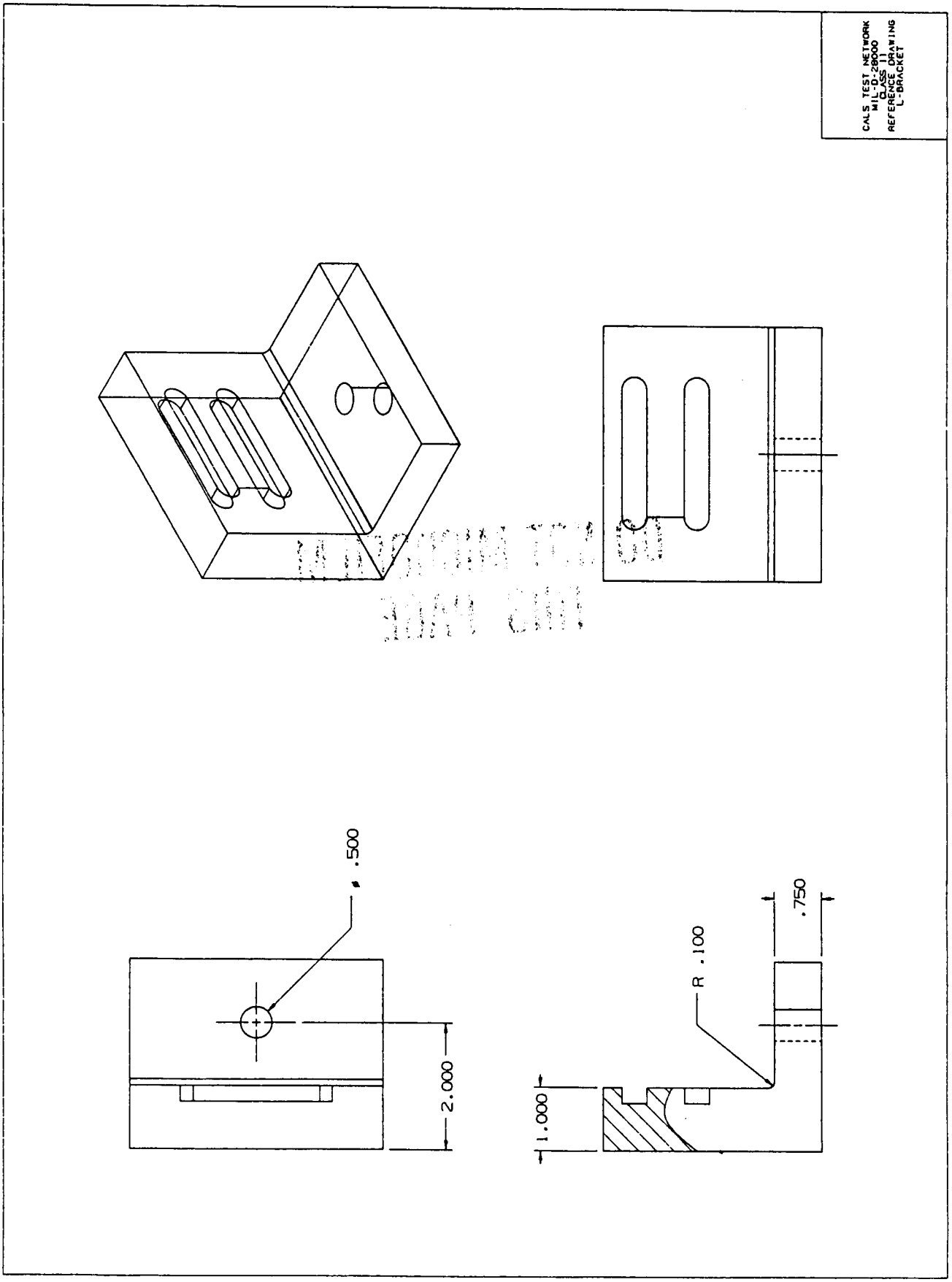


Exhibit 6 - DAC L-bracket Drawing After Post-processing



Appendix B- Entity Processing Explanations

1 - On the N-entity drawing, in one instance, UGII pre-processed a Composite Curve Entity (102) into the IGES file as the bounding curve of a bounded plane. In another instance, we tried to create an independent 102 by grouping the entities in the CAD model. Instead of pre-processing a 102, UGII mapped these grouped entities to a Group Without Back Pointers Entity (402 Form 7). UGII does not independently create the Composite Curve Entity. This is not an error, just UGII's mapping.

2 - On the N-entity drawing, the Composite Curve (102) contained a point, line, arc, and spline, but upon post-processing this entity, the point was blanked or not translated. The UGII code does not currently allow a Composite Curve to transfer a point. UGII has will address this issue in a futurerelease of the software, possibly using the group entity to group the point into the composite curve.

3 - We generated this conic arc using the coefficients of the equation. UGII did not pre-process this conic into a Conic Arc - General Equation Entity (104 Form 0), but mapped it instead into a Conic Arc - Ellipse (104 Form 1).

4 - This linear planar curve type entity was created by drafting a circular arc and then asking the system to break the arc into 20 short segments taking the form of the arc. This procedure created 20 short Line Entities (110) in the IGES file.

5 - The UGII drafting software did not allow us to enter the multi-segmented string in three dimensions as the N-entity generation script specified. Therefore, we entered this entity as three lines connected end to end. The lines pre-processed into individual Lines (110) in the IGES file.

6 - In one instance we created a centerline by inserting a line and changing the font of the line to a centerline font. This translated to a Line Entity (110) with a Centerline Line Font Pattern (DE 4 = 4) in the IGES file. In another instance, we created a centerline between two points and this properly created a Centerline Through Points Entity (106 Form 20) in the IGES file.

7 - Upon creating a crosshair centerline through the center of the circle, UGII created a Centerline Through Points Entity (106 Form 20) in the IGES file, but not the Centerline Through Circle Centers (106 Form 21) as expected. The appropriate graphics is still transferred.

8 - In one instance, UGII pre-processed the Simple Closed Area Entity (106 Form 63) into the IGES file in conjunction with the Sectioned Area (230) Entity. In another instance, we drafted a rectangle hoping it would pre-process as a 106 Form 63, but instead it transferred as four individual Lines (110). UGII does not independently create the Simple Closed Area Entity.

9 - UGII did not pre-process the Unbounded Plane (108 Form 0) as it should have. IGES specifies that View Entities (410) should point to Unbounded Planes which act as their clipping bounds. However, within UGII's IGES files, these Views pointed instead to Bounded Planes (108 Form 1) and this flagged errors in both conformance to IGES and to 28000. UGII's documentation claims that their Views point to Unbounded Planes, but our test showed this to be false. UGII will address this issue in a future software release.

10 - UGII pre-processed all ruled surfaces as Ruled Surface Entities with Equal Relative Parametric Values (118 Form 1) not as Equal Relative Arc Length Ruled Surfaces (118 Form 0).

11 - Again, the Ruled Surface with Equal Relative Arc Length Entity (118 Form 0) did not post-process into the UGII native database because UGII does not support it.

12 - A left handed transformation matrix is not a UGII option and therefore not pre–processed. All transformations were handled by the Right Handed Transformation Matrix (124 Form 0).

13 - The Rational B-Spline right circular cylinder-shaped figure was pre-processed into the general Rational B-Spline (RBS) Surface Entity (128 Form 0).

14 - The RBS cone-shaped figure was pre-processed into the general RBS Surface Entity (128 Form 0).

15 - The RBS sphere-shaped figure was pre-processed into the general RBS Surface Entity (128 Form 0).

16 - The RBS torus-shaped figure was pre-processed into the general RBS Surface Entity (128 Form 0).

17 - The RBS general quadratic was pre-processed into the general RBS Surface Entity (128 Form 0).

18 - The offset curve and the original curve were pre-processed into two independent Circular Arc Entities (100).

19 - The two arcs of the Offset Curve Entity (130) were not grouped upon post-processing as the UGII "IGES User Guide" says they should have been. UGII claims this is a misprint in the guide and it will be corrected. The arcs will not be grouped.

20 - The offset surface and the original surface were pre-processed into two independent surfaces, not into the Offset Surface Entity (140).

21 - The second surface of the Offset Surface Entity (140) did not post-process planar like it should have. This is a bug which UGII plans to correct in the next release when UGII implements a new Offset Surface Entity.

22 - During the post-processing of the Trimmed Parametric Surface Entity (144), UGII was not able to trace the spline curve, therefore could not complete the entity and trim the surface to this curve.

23 - IGES provides parameters to rotate text internally to create vertical text. UGII supports all aspects of text but this, so instead of creating vertical text, we entered horizontal text and rotated the whole text string by 270 degrees. Upon pre-processing, all aspects of text appeared in the General Note Entity (212 Form 0) of the IGES file except this internal rotation.

24 - The text "SIMPLE" was not post-processed vertically as specified by the Simple General Note Entity (212 Form 0), but it came in as horizontal text rotated 270 degrees instead. This occurred because UGII does not support vertical text. The slanting was properly post-processed.

25 - The dual stacked text was pre-processed as a Simple General Note Entity (212 Form 0).

26 - UGII did not support the special characters originally called out by the N-entity script (characters of the IGES Text Font 1002). As a result, we imbedded special characters that resembled the original ones. This new text was pre-processed as a Simple General Note Entity (212 Form 0) with imbedded characters from the IGES Text Font 1003.

27 - The symbolic characters imbedded in the text of the General Note - Imbedded Font Change Entity (212 Form 2) were missing upon post-processing. This occurred because UGII does not support all of the IGES Text Font 1002.

28 - The text containing the superscript was pre-processed as a Simple General Note Entity (212 Form 0).

29 - The text containing the subscript was pre-processed as a Simple General Note Entity (212 Form 0).

30 - The text containing both a superscript and a subscript was pre-processed as a Simple General Note Entity (212 Form 0).

31 - The left-justified, multi-stacked text was pre-processed as a Simple General Note Entity (212 Form 0).

32 - The center-justified, multi-stacked text was pre-processed as a Simple General Note Entity (212 Form 0).

33 - The right-justified, multi-stacked text was pre-processed as a Simple General Note Entity (212 Form 0).

34 - The text resembling a simple fraction was pre-processed as a Simple General Note Entity (212 Form 0).

35 - The text resembling a dual stack fraction was pre-processed as a Simple General Note Entity (212 Form 0).

36 - The text containing both a double fraction and an imbedded font change was pre-processed as a Simple General Note Entity (212 Form 0). We accidentally did not imbed a character with a different font, therefore did not test the pre-processing of this imbedded fonting in a dual fraction.

37 - The symbolic characters imbedded in the text of the General Note - Imbedded Font Change/Double Fraction Entity (212 Form 102) were missing upon post-processing. This occurred because UGII does not support all of the IGES Font 1002.

38 - The text resembling a super/subscript fraction was pre-processed as a Simple General Note Entity (212 Form 0).

39 - We were unable to change both the height and width of the wedge type arrowhead as desired. This is a limitation of the drafting package. Although the arrowhead size was not as specified, the leader was still properly pre-processed as a Leader with a Wedge Type Arrowhead Entity (214 Form 1).

40 - The Leader with a Wedge Type Arrowhead Entity (214 Form 1) was post-processed as a leader with a triangle type arrowhead.

41 - UGII does not support the filled triangle type arrowhead, therefore we drafted and then pre-processed the Triangle Type Arrowhead Entity (214 Form 2) instead. UGII is looking into implementing the filled triangle leader entity in its upcoming releases of its drafting package and IGES processors.

42 - The Leader with a Filled Triangle Type Arrowhead Entity (214 Form 3) was post-processed as a leader with a triangle type arrowhead.

43 - UGII does not support a leader with no arrowhead, therefore we drafted the triangle type arrowhead instead and then deleted the arrowhead. This pre-processed as a Leader with a Triangle Type Arrowhead Entity (214 Form 2) with the arrowhead height and width equal to zero. UGII is looking into implementing the no arrowhead leader entity in its upcoming releases of its drafting package and IGES processors.

44 - UGII does not support the filled circle type arrowhead, therefore we drafted and then pre-processed the Circle Type Arrowhead Entity (214 Form 5) instead. UGII is looking into implementing the filled circle leader entity in its upcoming releases of its drafting package and IGES processors.

45 - The Leader with a Filled Circle Type Arrowhead Entity (214 Form 6) was post-processed as a leader with a circle type arrowhead.

46 - UGII does not support the rectangle type arrowhead, therefore we drafted and then pre-processed the Circle Type Arrowhead Entity (214 Form 5) instead. UGII is looking into implementing the rectangle leader entity in its upcoming releases of its drafting package and IGES processors.

47 - The Leader with a Rectangle Type Arrowhead Entity (214 Form 7) was post-processed as a leader with a circle type arrowhead.

48 - UGII does not support the filled rectangle type arrowhead, therefore we drafted and then pre-processed the Circle Type Arrowhead Entity (214 Form 5) instead. UGII pis looking into implementing the filled rectangle leader entity in its upcoming releases of its drafting package and IGES processors.

49 - The Leader with a Filled Rectangle Type Arrowhead Entity (214 Form 8) was post-processed as a leader with a circle type arrowhead.

50 - UGII does not support the integral sign type arrowhead, therefore we drafted and then pre-processed the Slash Type Arrowhead Entity (214 Form 9) instead. UGII is looking into implementing the integral sign leader entity in its upcoming releases of its drafting package and IGES processors.

51 - The Leader with an Integral Sign Type Arrowhead Entity (214 Form 10) was post-processed as a leader with a slash type arrowhead.

52 - UGII does not support the open triangle type arrowhead, therefore we drafted a triangle type arrowhead and modified the leader line to make the arrowhead resemble an open triangle. This entity then pre-processed as a Triangle Type Arrowhead Entity (214 Form 2). UGII is looking into implementing the open triangle entity in its upcoming releases of its drafting package and IGES processors.

53 - The Leader with an Open Triangle Type Arrowhead Entity (214 Form 11) was post-processed as a leader with a triangle type arrowhead.

54 - Because UGII does not have a drafting entity called a point dimension, we drafted an ID symbol closely resembling a point dimension. This symbol then pre–processed as a General Symbol Entity (228 Form 0).

55 - The particular general symbol shape that the N-entity generation script calls for was not supported as a single symbol by UGII. Because of this, we generated the shapes as separate entities, and they pre-processed as such. But, in general UGII does support the Symbol Entity (228 Form 0).

56 - UGII post-processed the text and the line of the General Symbol (228 Form 0), but did not process the diamond-shaped Simple Closed Area (106 Form 63). This is a UGII bug and will be corrected.

57 - The symbol representing a datum feature was pre-processed to a General Symbol Entity (228 Form 0).

58 - The symbol representing a datum target was pre-processed to a General Symbol Entity (228 Form 0).

59 - The symbol representing a feature control frame was pre-processed to a General Symbol Entity (228 Form 0).

60 - The text and the box of the post-processed Feature Control Frame Symbol Entity (228 Form 3) overlapped. This is a problem with font sizes and intercharacter spacing and can be attributed to both the CTN Reference File and to UGII. In one instance, the text ".02" overlapps with the right side of the frame because of an oversight in the CTN Reference File. This will be corrected in the next release of the "CTN Reference Drawing Packet". In the other instance, the special character representing perpendicularity is too large for the box and larger than allowed by the "ANSI Dimensioning and Tolerancing" standard [ANSI82]. This is a UGII oversight.

61 - The crosshatching that pre-processed as a Sectioned Area Entity (230) was not flagged as annotation as it should have been. Also, the 230 incorrectly points to a Simple Closed Area Entity (106 Form 63) as the boundary curve. This is incorrect because the Simple Closed Area Entity is not really a curve. UGII will address these issues in future software releases.

62 - The dashed line information was pre-processed into a Line Entity (100) with a dashed line font not processed into the Line Font Entity - Repeating Subfigure Pattern (304 Form 1).

63 - UGII does not claim to post-process this Line Font Entity - Repeating Subfigure Pattern (304 Form 1), but does correctly substitute the default line font the entity specifies. This is shown on the front view of the L-bracket drawing by particular hidden slot lines.

64 - The dashed line information was pre-processed into a Line Entity (100) with a dashed line font, not processed into the Line Font Entity - Repeating Visible/Blank Pattern (304 Form 2).

65 - UGII does not claim to post-process the Line Font Entity - Repeating Visible/Blank Pattern (304 Form 2), but does correctly substitute the default line font the entity specifies. This is shown on the top view of the L-bracket drawing by other hidden slot lines.

66 - The subfigure definition, or reference set information as UGII calls it, was not pre-processed as a Subfigure Definition Entity (308) but as information encapsulated in the Group without Back Pointers Entity (406 Form 7). The one default with this mapping is that 406 Form 7 is not a 28000 Class II entity.

67 - The color information was pre-processed into the DE Section Field Number 13 of the IGES file, not processed into the Color Definition Entity (314). This is not an error, just UGII's mapping.

68 - UGII did not pre-process the Views Visible Entity (402 Form 3). The consequence of this is that any lines originally blanked from one or two of the four views will appear in all views and cover up special detailing like centerlines or dashed lines. UGII plans to implement this entity in the next software release.

69 - UGII did not pre-process the Views Visible, Color, Line Font Entity (402 Form 4). This means that the translation looses the information about the different colors and line fonts an entity may have in different views. Few systems process this entity.

70 - UGII did not post-process the Views Visible, Color, Line Font Entity (402 Form 4). This is seen on the L-bracket drawing which displays dashed lines and centerlines not appearing as they should. UGII claims not to support this entity.

71 - UGII pre-processed grouped entities into the Group without Back Pointers Entity (402 Form 7). 28000 Class II does not identify this entity, but specifies the Ordered Group without Back Pointers Entity (402 Form 15) instead. The CTN will recommend that 402 Form 7 be added to Class II because of its wide support by UGII and other CAD vendors.

72 - When drafting the L-bracket part, we created a Drawing which UGII pre-processed into a Drawing Entity (404). When drafting the N-entity part, we neglected to create a Drawing (UGII does not require one), and UGII did not pre-process a Drawing Entity. This brings up an issue of ambiguity in 28000 regarding whether or not a Drawing is required. The CTN technical staff will request clarification and rewording of 28000 to make it clear that a Drawing Entity is required in every IGES file.

73 - UGII did not pre-process the Definition Levels Entity (406 Form 1). UGII claims not to support it.

74 - On the L-bracket drawing, the subfigure entities (the entities making up the lower slot) did not post-process onto both levels 1 and 4 as they should have. The Definition Levels Entity (406 Form 1) requested this, but UGII does not support this concept in the drafting package or in the processor software.

75 - UGII did not pre-process the meaning or intended use of the level information into the Level Function Entity (406 Form 3). UGII does not claim to support this entity.

76 - UGII does not allow creation of a widened model line that will pre-process into a Line Widening Entity (406 Form 5), therefore, we did not draft a widened line into the L-bracket drawing as the script requested.

77 - During post-processing, UGII did not widen the specified model line of the L–bracket drawing. This is understandable because UGII does not claim to post-process this Line Widening (406 Form 5) Entity.

78 - The subfigure instances, or components as UGII calls them, were not pre–processed as subfigures, but as Group without Back Pointer Entities (406 Form 7).

Appendix C - References

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