

The need for CAD Standards

In this workshop, we describe our experience gained when assisting a number of companies manage the production of drawings by design drafters working for a variety of 'outside' contracting organizations. The projects have ranged from the 'blending' of a series of CAD drawings for part of the expansion and upgrading of a chemical plant with a existing set of several thousand CAD drawings, to the generation of a set of concept and detail drawings for the construction of a 'Centre for the Performing Arts', to commissioning a set of civil engineering drawings for a local government council. In each case, we have found that the production of a **CAD standards manual** has helped enormously to smooth the project path.

A generic CAD standards manual

Since we provide consulting services to a variety of clients who all have different requirements, we have found that the best way to start is to 'cannibalize' a generic CAD standards manual; altering it so that it matches the new requirements. The outside group (client) is then given clear guidelines as to the arrangement of the required drawings.



A copy of this file (in Microsoft Word format) has been placed in the Exercises folder on the workshop CD-ROM and can be freely copied from there.

A bonus

In many cases there is an added benefit in producing a CAD standards manual, because the manual not only functions as project guide but also as a CAD user guide within the 'host' company for the use of 'internal' drafting staff.

The structure and content of the generic CAD standards manual is discussed below.

A CAD standards manual is a controlled document

The manual is likely to be a controlled document and exist as part of a quality system. As a result, the name of the author, creation date, revision status etc. should be recorded with appropriate headers and footers. Create the document using a professional word processor such as Microsoft Word.

1. Include a table of contents

We have found it most useful if the manual has an accurate table of contents and an index. This makes it more likely that the manual will be used. The figure below shows part of a typical table of contents which should be created using an automatic table generator. We have used the table generator in Word which is an enormous time saver and reduces error.



If you do not know how to create a table of contents from an existing document, enrol for our 'Advanced Word' course. The details of the course syllabus can be found on our web site - www.designcad.com.au.

INTRODUCTION	1
CAD SOFTWARE	3
RESPONSIBILITIES OF STAFF	3
REFERENCES, STANDARDS ETC.	3
PROCEDURES FOR CAD	4
STARTING A NEW DRAWING	4
DRAWING SHEETS	4
SHEET SIZES AND BORDERS	4
NAMING CONVENTIONS	5
Isis notation	5
Reader Issues	5
Approved Drawings	5
SIZES, UNITS, DIMENSIONING, SPACES AND SCALES	6
USE OF COLOUR	6
LINETYPES	7
LAYERS	7
Layer List without modifiers	7
Layer List with Modifiers	7
BLOCKS	9
TEXT	9
LANGUAGE	9
DRAWING REVISIONS	9
CONTRACTOR'S LOGO	10
CROSS REFERENCES	10
SURVEY REQUIREMENTS	10
PLOTTING	10

A table of contents created automatically using Microsoft Word.

2. The introductory section of the manual

The manual should have some sort of general introduction. This section should indicate the reason for producing the document and why people should be following it. E.g. *'This document describes Computer Aided Design (CAD) procedures to be adopted on projects at ACME Design (the company). It is to be used internally as an office standard and issued to outside consultants. The aim is to provide a sound basis for the production of electronic drawings in the particular discipline required'*.

Mention might be made in the introduction that guidance for arrangement and transmission of files during the project management cycles is also provided in the document.

3. Indicate CAD Software to be used

A clear statement should be made regarding the software to be used. Something along the lines of 'Drawings will be electronic using the latest version of **MicroStation** (or PowerDraft software from Bentley Systems). Alternatively, 'All CAD drawings are to be drawn using a CAD program capable of reading and writing drawing files in .DWG format without conversion. This would allow the use of **IntelliCAD**, **AutoCAD** or **AutoCAD LT** (or other CAD programs which use the OpenDWG tools in their software) and does not proscribe the use of the very latest version by different software vendors.

You for greater consistency, you might include a statement along the lines of 'Drawings are to be saved as (e.g.) AutoCAD Release 14 format. Drawings are not to be converted from other CAD software, even though these programs may have a DXF output module'. DXF translators are notoriously unreliable and adding this requirement can prevent costly translation errors.

4. Nominate staff responsibilities

The responsibilities of staff and contractors need to be made very clear in the manual. To whom does this standard apply? For example, *'this procedure applies to any staff member of a design group preparing CAD drawings in any discipline and to outside contract organizations delivering CAD drawings to ACME Design'*. Or, *'the manual applies to the production of all drawings and documents for project and engineering work. It affects all vendors, consultants, and contractors, project engineers, discipline engineers and drafters'*.

5. List references, standards etc.

It is most useful to include a comprehensive list of all the standards that you expect drafters will use in the production of their work. The figure below shows one such example.

References, standards etc. ¶

AS1000-1979+ → The International System of units (SI) and its application ¶

AS1000.101-1992 → Technical Drawing ¶

→ → → Part 101: → → General Principles ¶

→ → → Part 201-1992 → Technical Drawing ¶

→ → → Part 201-1984 → Mechanical Engineering Drawing ¶

AS1101.5-1993 → Graphical Symbols for General Engineering ¶

Part 1: → Hydraulic and Pneumatic Systems [ISO title: Fluid power systems and components - Graphic symbols on circuit diagrams, Part 1: Graphic symbols] ¶

AS1101.5-1984 → Graphical Symbols for General Engineering ¶

Part 5: → Piping, Ducting and Mechanical Services for Buildings ¶

AS1101.5-1984 → Graphical Symbols for General Engineering ¶

Part 6: → Process Measurement Control Functions and Instrumentation ¶

AS1102 → → Graphical Symbols for Electro-Technology ¶

AS1103 → → Diagrams, Charts and Tables for Electro-Technology ¶

AS1122 → → Recommended Metric Sizes for Engineering ¶

AS1155 → → Metric Units for use in the Construction Industry ¶

AS1203-1979+ → Microfilming of Engineering Documents ¶

AS1212 → → Scale Rules ¶

AS1224 → → Preferred Sizes of Building Components ¶

It is rather obvious, but make sure that each article is referenced correctly. If you have placed any additional standards on your web site, give the correct locations URL on your web site thus: (<http://www.designcad.com.au/support/cad/Standards/cadstandards.htm>).

6. Nominate step by step procedures for CAD

After discussing general issues, we have found that the most effective way to help a drafter come to grips with what the company is aiming for, is to take them metaphorically through the creation of a CAD drawing. This helps even very experienced drafters 'come to grips' with the way in which the company requires CAD drawings produced. Experienced workers have often become very set in their ways of working and need some gentle coercing to move to a slightly different way of doing things. It is really helpful if you include diagrams (screen grabs) in your document wherever possible to illustrate the steps involved.

6.1 Starting a new drawing

Explain how to start the CAD program? Are you going to use MicroStation Workspace or AutoCAD default drawings? Do you expect the CAD designer to use a particular template or series of seed files? What configuration variables need to be set before beginning?

6.2 Identify the drawing sheets to be used

Once the seed or default file loads, you would expect the drafter to insert a drawing sheet with its appropriate title block.

Q. Are you going to provide a set of title block drawings?

Q. Are these files on a 'virus free disk' that you can confidently give to contractors?

Q. Have you checked that the sheets are true to type with sheet sizes, border offsets according to AS1100? We have seen a situation where a title block Drawing issued by a prime contractor failed to load in a CAD program.

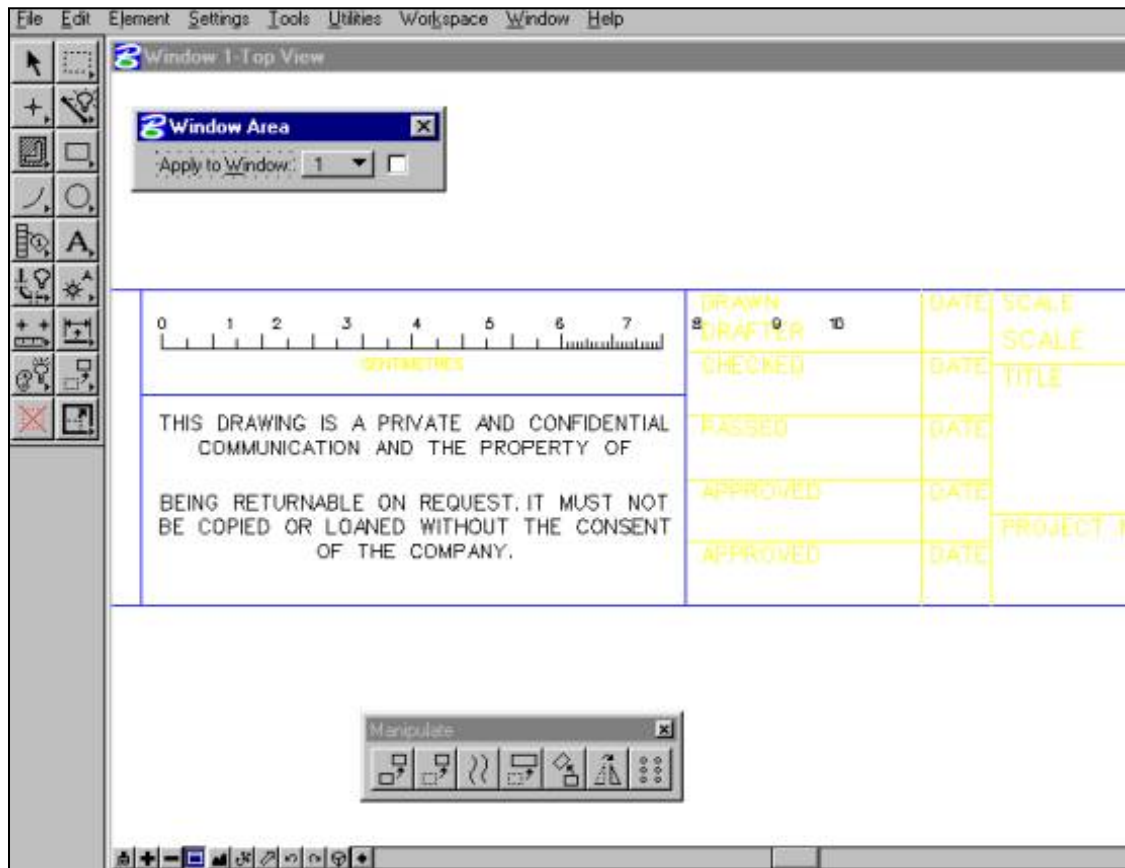
Q. Do these title block drawings contain attribute tags or replaceable text holes? Some notes explaining how attributes were set up would be useful. It is usual to expect users to fill out the required attribute information in the title block as the sheet is inserted. Make it clear that users are not to 'drop cell' or 'explode' attributes after insertion and give the reason 'the company extracts tag information from groups of drawings for its drawing register database.

Q. Will sheet drawings be inserted as sheet files (or in paper space)? Have you tested that they work well?

Q. How is layering organized in the title block? Something along the lines of 'all title block information is placed on a level 36 (layer BASE) and the drawing border (including a horizontal line to 'fence' off the title block area) on a level 37'. One standard includes the

note that attributes for parameters such as checked have not been set as the company prefers a signature rather than CAD text to indicate acceptance of a design. Remember that diagrams help.

Use examples. The figure 3 shows an example (part of the title block area of the A1 sheet used for mechanical drawings).

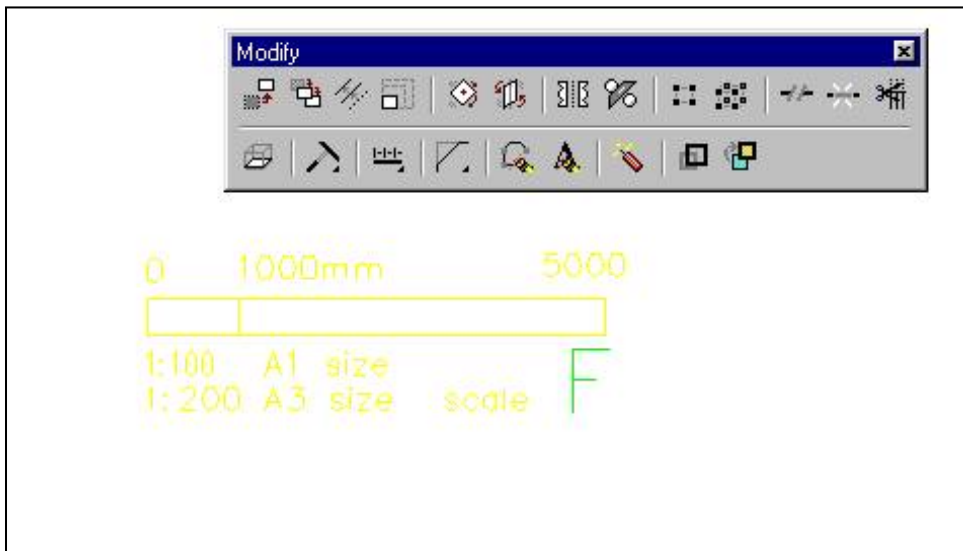


Incidentally, in this case, the drafter imported the drawing from AutoCAD to MicroStation without taking care to match fonts. Notice the way in which text spacing causes errors in the scale marker. This was easily detected here, but could have been a problem if the error was not obvious.

Give some indication as to sheet sizes to be used in different disciplines. Such as, 'As a general rule, the company requires mechanical drawings on A1 sheets, architectural/mechanical/electrical services on A0 sheets, process and instrumentation drawings on A1 sheets, electrical schematic drawings on A3 sheets and instrument loop drawings on A3 sheets. Note that these latter A3 drawings will commonly be reduced in size by photocopy reduction for inclusion in field manuals'.

Or, 'All drawings will be produced on A1 sheets. However, for field use we also require our A1 drawings to be plotted on A3 sheets, changing scale automatically'.

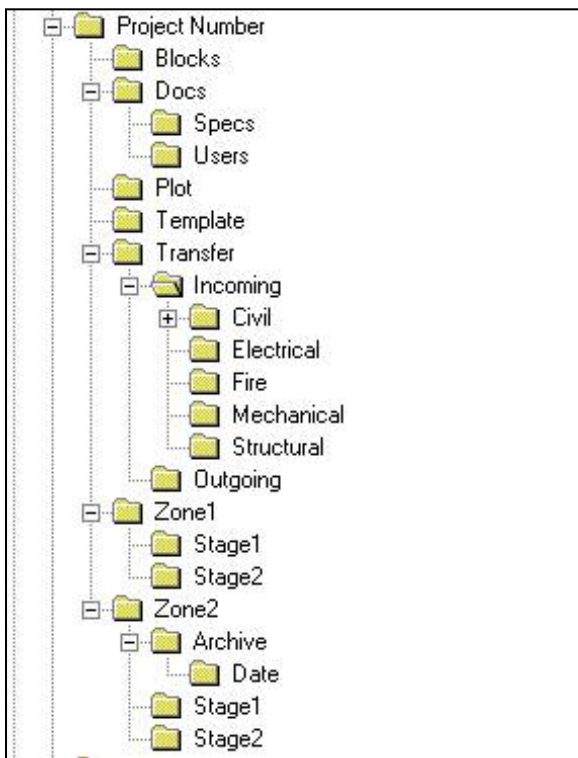
The figure below shows a special scale cell used for this purpose. Is a collection of cells of this type is provided on the contractor disk?



6.3 Project structure

It is most useful to store all data for a project together and useful to publish the folder structure, including the use of file names.

A statement along the following lines 'Projects are broken down into distinct zones, phases or packages. The extent of this subdivision depends on the size and nature of the project. Each zone, sector or phase should have its own directory and, depending on the complexity of the project, these directories can form a hierarchy as illustrated in the figure below'.



Additional explanation may be necessary here. E.g. 'A sub-directory Docs is created under the project directory. For small jobs, all Word documents are saved to this location. For larger projects, separate sub-directories are created with the author initials and a separate sub-directory for the specification called Spec.'

6.4 Plotting drawings

We also add comments on plotting 'When plotting drawings, a plot (.PLT) file is to be created and saved to the Plot directory. .PDF files are an alternative. This file is then copied to the appropriate output device or issued to the recipient. The file name is to include the drawing number and the issue number/letter'.

Sub-directories may be created under the plot directory for various issues, Tender, Construction approval etc. Superseded hard copies may be discarded, as there is an

electronic copy.'

Standard template files are to be used wherever possible. If specialized seed (or default) files are required, they are saved to a Seed folder with a name reflecting their intent, e.g. Plan, Site, Landscape.'

6.5 File naming conventions

Comments need to be made regarding naming systems. One introduction to this section read 'Working files are those that contain the model (or drawing database). These are normally referenced into sheet files. Older systems using DOS had a restriction of 8 characters and 3 characters for the extension. Our company uses 32 bit operating systems that allow longer file names, however, we have restricted ourselves to a maximum of 17 characters for file name plus 3 for the file extension. For simple projects that do not contain multiple zones in multiple drawings, file naming is to be in the following format. A 123 PL 01 .DWG or DGN where A represents the discipline – A for architecture, L for landscape architecture, P for planning, D for interior design, M for marketing etc. the 123 represents the project number, the PL represents the file description – PL for plans, EL for elevations, SE for sections, SI for site plans etc while the final two characters are for multiple occurrences of similar file descriptions. 01 is always the first file.

Another specification was much more simply written viz., 'Drawing numbers will be supplied to contractors by ACME Design office staff.'

6.6 Sizes, units, spaces and scales

The use of master units and sub-units needs to be carefully defined. For AutoCAD users, a statement thus 'AutoCAD drawing units are taken as mm. All objects are to be drawn full size in tiled model space. Adopting this strategy means that any enquiry in model space (listing of an entity in AutoCAD or use of the DISTANCE command) can be made of any drawing and true distances (in mm) will be reported.

To reiterate, all objects are drawn actual size, do not draw in the sheet files.' Might be used. While in a MicroStation environment 'All drawings shall be created full size (active scale=1) and the border scaled to suit, using reference files. Scales shall be preferred metric scales to AS 1100'.

6.7 Use of colour

Colour can be controlled by level (layer) or set implicitly or even a combination of the two. Confusion reigns if this issue is not dealt with clearly in the CAD standards.

An AutoCAD specification might state '*The use of colour in CAD drawings will conform to the ISO colour system, which is loosely based on the Rotring pen colour coding system commonly used in manual drafting. The following colours are to be used. The number column indicates the pen number as shown in the AutoCAD plot configuration dialogue box*'.

The table below shows AutoCAD settings.

Colour	Number	Pen Width (mm)
Grey	8	<0.18 (preferred)
Magenta	6	< 0.18
White	7	0.25
Yellow	2	0.35
Red	1	0.50
Cyan	4	0.70 (preferred)
Blue	5	0.70
Green	3	1.00
Dark Grey	250	75%
Dark Grey	251	60%

Grey	252	45%
Grey	253	30%
Light Grey	254	15%
White	255	0%

6.8 Greyscale

The use of pens 250 to 255 is used when outputting to HPGL2 devices to obtain constant and smooth shading. Pen 255 has 0% shading when white lettering is required on a background.



Note that the order of the text and the background is important to achieve the desired result. The DRAWORDER command can be used here.

You might well say "*In all cases, colour will be controlled by implicitly specifying the colour property of the entity on insertion and not by using AutoCAD's colour BYLAYER system.*"

For MicroStation, the table below shows typical settings for levels, colour, pen weights and line codes.

Level Colour Weight Line Codes Description

Level	Colour	Weight	Line Codes	Description
20	1	2	LC=0	All indicators such as scale cells and North arrows
22	3	4	LC=1	Section and Details
24	2	2	LC=1	General Plan
25	4	2	LC=2	Match lines for sheets
27	0	1	LC=3	Equipment/location boundary
28	5	0	LC=2	Revision clouds and text
29	0	1	LC=1	Dimension text
30	0	0	LC=1	Witness lines

6.9 Levels and layers

An AutoCAD example: '*Drafting in all disciplines will begin on a layer called BASE (not layer 0 in AutoCAD)*'.

Many drawings can satisfactorily be completed using this single layer, assigning pen weights to colour on this layer as required.

If it is necessary to create new layers, you might say something along the following lines '*The company will allow any sensible naming convention but please be specific, e. g. Existing_Pipework, Town_Water. We would encourage you to use (but not mandate) the layer/level naming convention (guidelines) published by the task force sponsored by the American Institute of Architects, the American Consulting Engineers Council, the International Facility management Association, the Naval Facilities Engineering Command, the United States Army Corps of Engineers, the American Society of Civil Engineers and the Department of Veterans Affairs shall be used. These guidelines cover the AEC (Architecture, Engineering and Construction) industries.*'

A MicroStation example: 'Elements will be placed on levels 1-63. The levels have been pre-loaded into a seed file with appropriate naming conventions.'

6.10 Text

An **IntelliCAD/AutoCAD** example:

'The ISO3098B font will be used for all lettering with heights of text inside drawing sheets

as per AS1100 (AS1100.101 -1992, Section 4 1.5). The AutoCAD styles Romand (with font Romand) and Romans (with font Romans) are used in title block information, but are not to be used inside the sheet. In AutoCAD, the style ISO3098B is defined as follows:

Style	ISO3098B
Font	ISO3098B.SHX
Height factor	0.0
Width factor	1.0

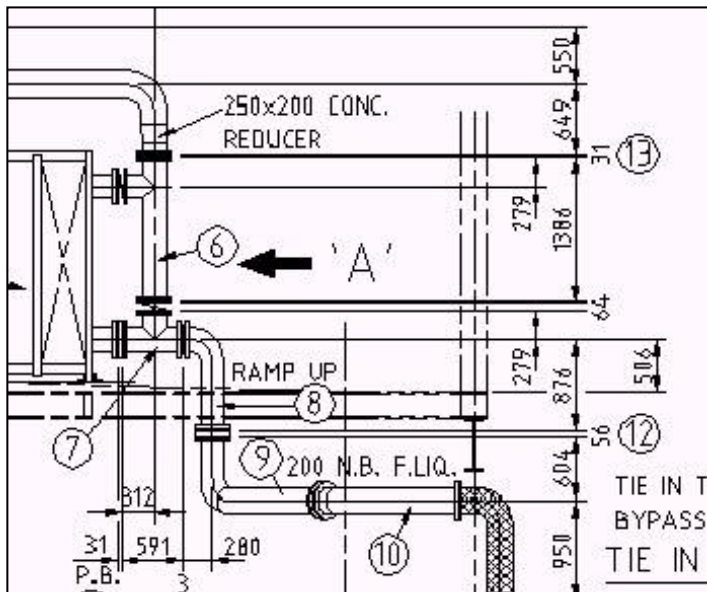
Final text height (h) sizes will be 2.5, 3.5, 5.0, 7.0, 10, 14 and 20 mm as required by AS1100 (4 2). The minimum height of text is controlled for ensuring clarity. On A0 sheets minimum text height is to be 3.5 mm in general notes, materials lists and dimensions. We also prefer 3.5 mm as the minimum height for these elements in the A1 to A4 sheet series.

For MicroStation: 'Text shall be ISO font 27. The Ausfont series will be used. Text height will be set equal to text width (TX=TH=TW). Sizes to AS1100 1.8 mm, 2.5 mm, 3.5 mm (preferred size), 5.0 mm and 7.0 mm. Font 102 will be used for arrowheads. Text line spacing shall be one half of the text height (LS=0.5TX). Text leaders and arrowheads shall be on the same level as the text. Notes shall be placed at the bottom right hand corner of the drawing next to the title block.'

6.11 Dimensioning

Comment and guidance is needed for dimensioning. E.g. '*Dimensioning should normally be expressed as mm. Dimensions of less than unity should be preceded by zero eg. 0.6 mm. Each dimension should appear only once and not repeated in other views. Dimensions should be placed outside the component if possible. Dimension text should also be placed so that it may be read from bottom or right-hand side of the drawing*'.

Give an example. The figure below shows a part dimensioned to the company style.



6.12 Use of presentation space (Paper Space)

The paper space tool in AutoCAD/IntelliCAD can be used with good effect.

Since the usual intention when using paper space is that parts of the design will be displayed in paper space at different scales, differing dimension settings will be needed on each part of the design. Dimension arrowheads and text sizes need to be consistent across the final presentation sheet (in paper space).

In order to do this, we create a master dimension style named DIM-XXX where XXX is the largest scale to be used in the drawing. As an example, the dimension system variables for

a style DIM-100 are printed in the Appendix: The Dim-100 style is set in the paper space template and a copy is available on the contractor disk.

6.13 Checking and auditing

We find that the use of a program such as 'Enforcer' [MicroStation] or 'Verify' [AutoCAD/IntelliCAD] to test a drawing files against the standard published in this manual is invaluable. These programs work by analyzing a drawing for text styles, heights, scales, level and layer use etc. and then compare what they have found with a text file listed approved usage.

6.14 Transmittal and file compression of drawings during project life

Contractors often need help in this regard. 'It is more than likely that a set of drawings and documents will not fit onto a single floppy disk. To compress all the drawing files for transmission, including files in sub-directories' use the shareware program WINZIP.EXE ®. If there is a need to span these compressed files across multiple floppy disks use the DOS shareware program PKZIP®. A copy of PKZIP is included on the contractor disk in the folder called compress. The note below contains instructions on using this program. The following syntax is commonly used:

```
PKZIP /&rp a:\[filename]*.*
```

/ Switch command.

& Forces pkzip to span multiple floppy disks.

r Searches all sub directories and compresses all files.

p Stores all sub directory information for decompression.

Files stored on multiple floppy disks can be decompressed by using the companion shareware program, pkunzip with the -D switch to re-establish the sub-directories structure viz:

```
PKUNZIP -D A:\FILENAME C:\DIRNAME'
```

6.15 Pack and Go

If firms have access to AutoCAD's 'Pack and Go' feature, then we encourage its use. A comprehensive document on Pack and Go can be viewed at www.designcad.com.au and click on the support link.

6.16 Checking drawings

State clearly the checking system that will be used, whether an automatic system such as VERIFY or a manual system.

Conclusion

The above discussion covers some of the important issues that we believe needs to be defined in a CAD manual in order that a consistent set of CAD drawings for a project are produced. Our discussion is by no means exhaustive. We find that each project has some special needs but, by altering our standard procedure manual, we can generate special purpose procedure manuals quickly and easily.