

Working Drawings and Assemblies

Production or working drawings are specialized engineering drawings that provide information required to make the part or assembly of the final design. Working drawings rely on orthographic projection and many other graphical techniques (sectioning, dimensioning, tolerancing, etc.) to communicate design information for production.

Basic Concepts

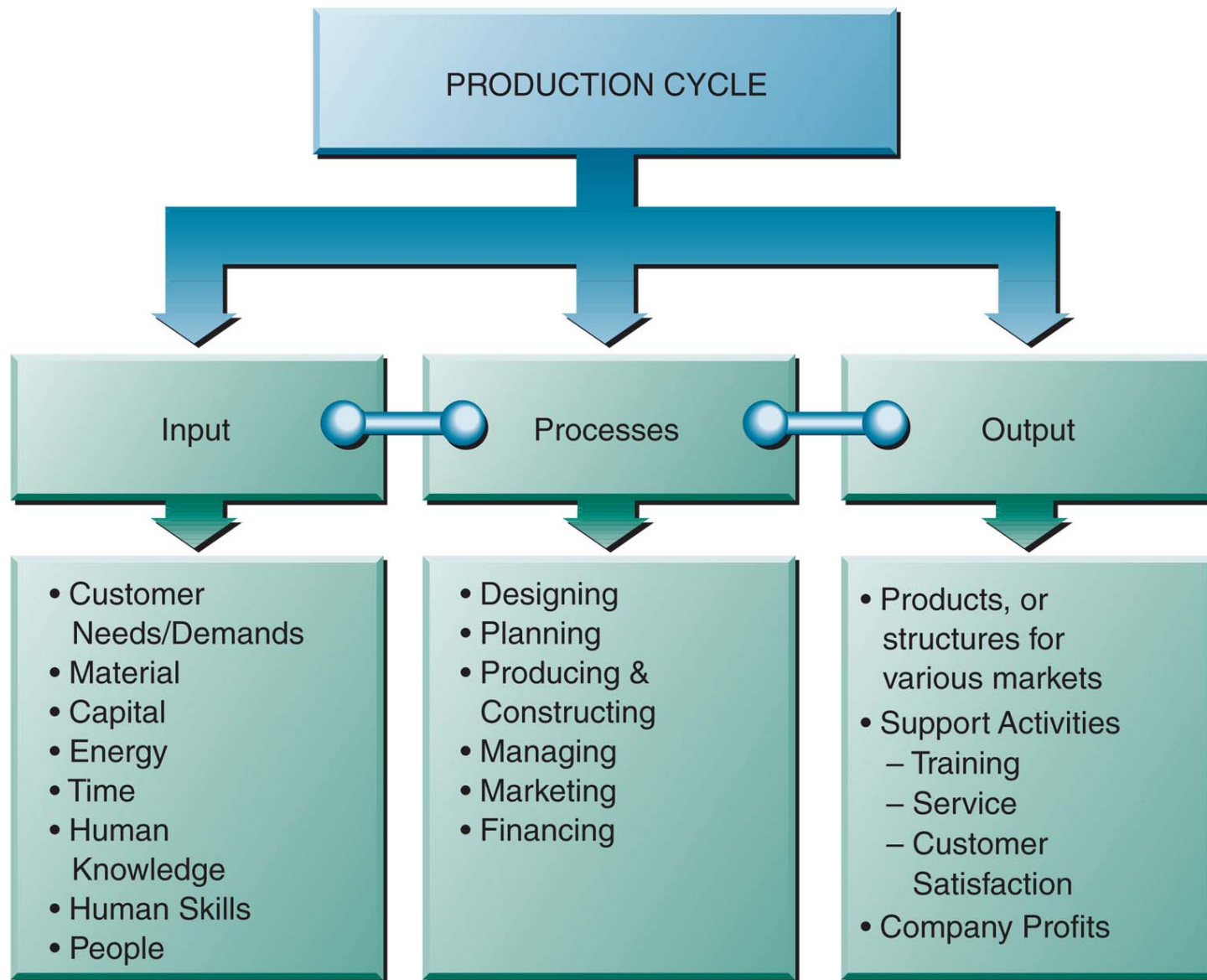
Engineering drawings are used to

- communicate designs to others (client, colleagues, boss...)
- document design solutions, and
- communicate design production information (to manufacturer).



For the communication of the final design for *production purposes* we use the types of drawings which are called **working drawings** or **production drawings**.

In the following figure you can see the components of the production cycle:



On all steps the production cycle includes documenting as a major process.

Documenting in designing is the process of communicating and archiving design and manufacturing information on a product or structure.

The documents created in the design stage include

- * drawings,
- * models (produced with CAD software),
- * change orders,
- * memos, and
- * reports.

Traditional processes: storing, retrieving, copying engineering drawings (*reprographics*).

Archiving is part of reprographics.

Modern manufacturing: with 3D CAD and modern manufacturing techniques the need for production drawings is minimized.

Instead of creating 2D drawings of the 3D model, production information and geometry is extracted directly from the computer model.

Electronic file storage and distribution eliminate the need for many traditional reprographics activities.

However, **working drawings** are still used to produce products, structures, and systems.

***Working drawings** are the complete set of standardized drawings specifying the manufacture and assembly of a product based on its design.*

- o The complexity of the design determines the number and types of drawings.
- o Working drawings may be on more than one sheet and may contain written instructions called **specifications**.
- o Working drawings are the *blueprints* used for manufacturing products.

Requirements to the set of drawings:

- ☒ completely describe the parts, both visually and dimensionally
- ☒ show the parts in assembly
- ☒ identify all the parts
- ☒ specify standard parts.

Basing on the abovementioned criteria, generally, a complete set of working drawings for an assembly includes:

1. Detail drawings of each nonstandard part.
2. An assembly or subassembly drawing showing all the standard and nonstandard parts in a single drawing.
3. A bill of materials (BOM).
4. A title block.

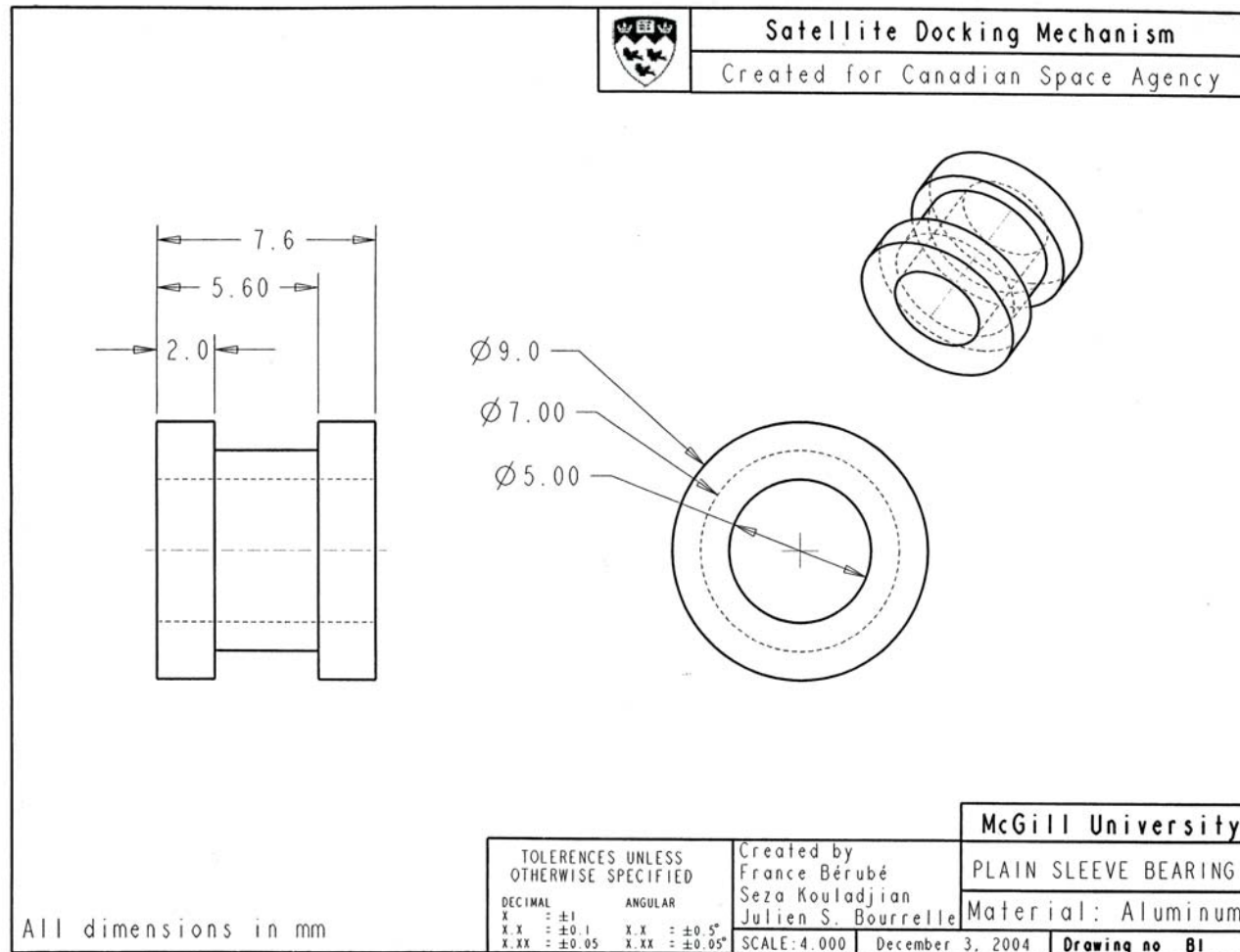
Thus, the two main types of the drawings in this set are:

- ✓ *A Detailed Drawing*
- ✓ *An Assembly Drawing*

Structure of the set of working drawings:

- ❖ High level assembly (assembly of subassemblies, or units)
- ❖ Subassembly / subassemblies (Low level assemblies)
- ❖ Detailed drawings.

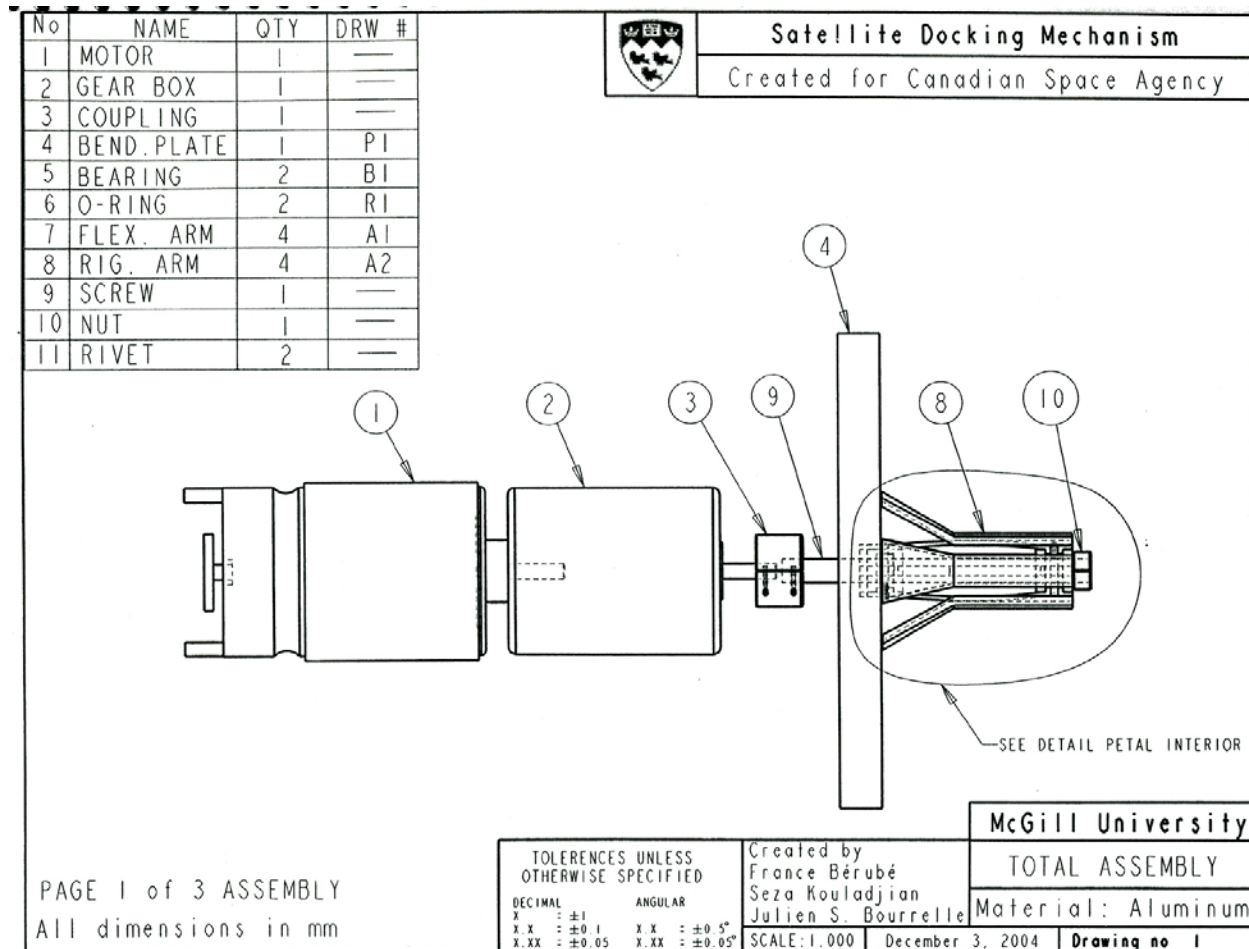
A **detail drawing** is a dimensioned, multiview drawing of a single part, describing the part's shape, size, material, and finish, in sufficient detail for the part to be manufactured based on the drawing alone.



Detail drawings are produced from design sketches or extracted from 3-D computer models.

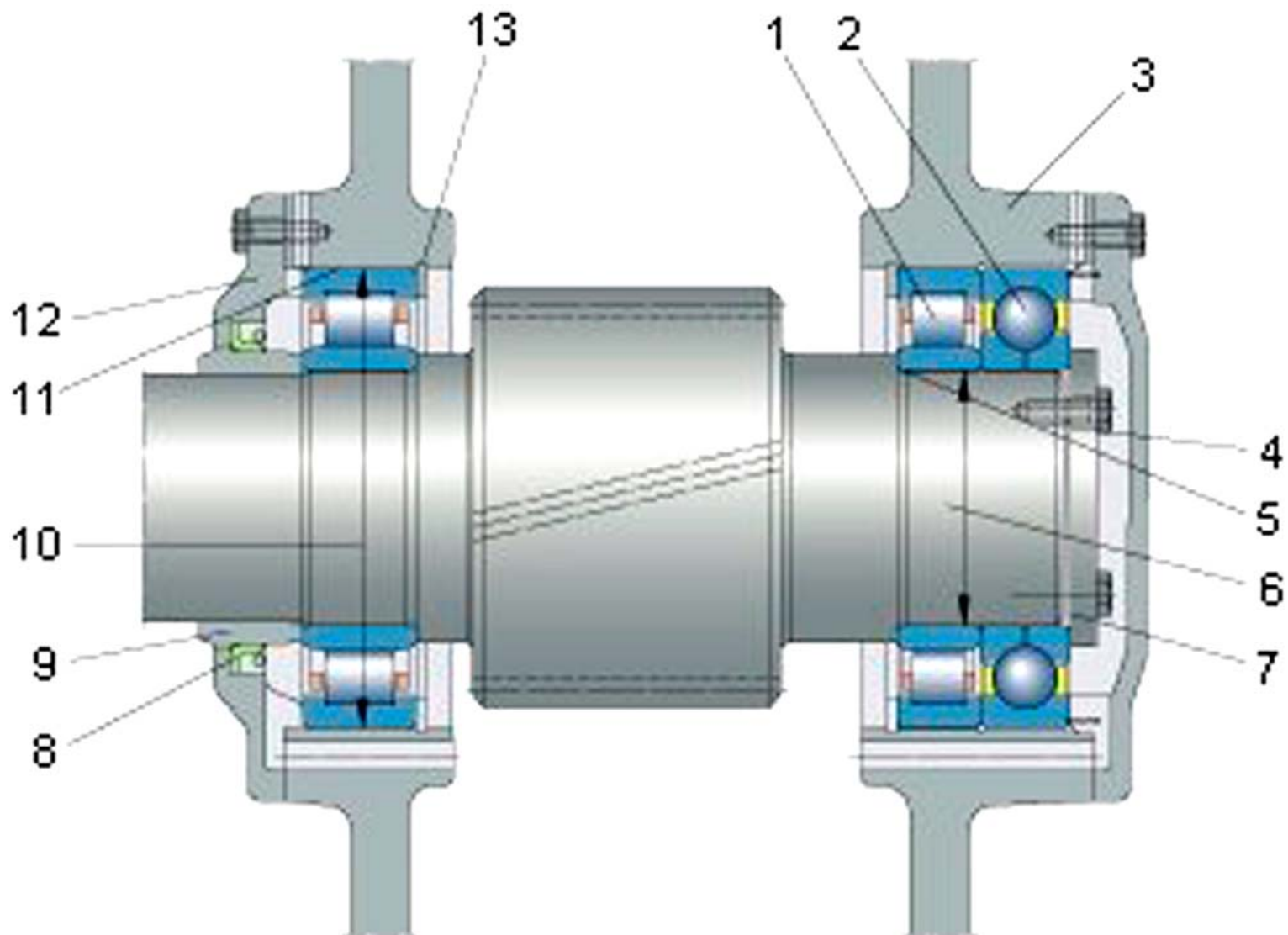
If the assembly is simple or the parts are small, detail drawings for each part of an assembly can be placed on a single sheet. When more than one detail is placed on a sheet, the spacing between details is carefully planned, including leaving sufficient room for dimensions and notes.

Standard parts (threaded fasteners, bushings, bearings) *are not drawn as details* because they are normally purchased, not manufactured. However, they are shown in the assembly views.

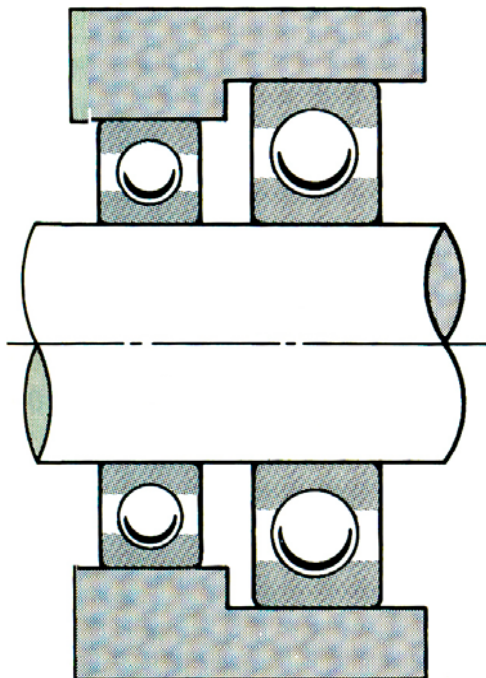
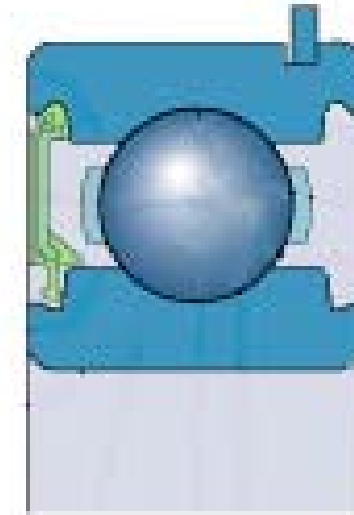


If you show sectioned assembly, motors don't have to be sectioned.

Bearings should be sectioned when assembly is sectioned.

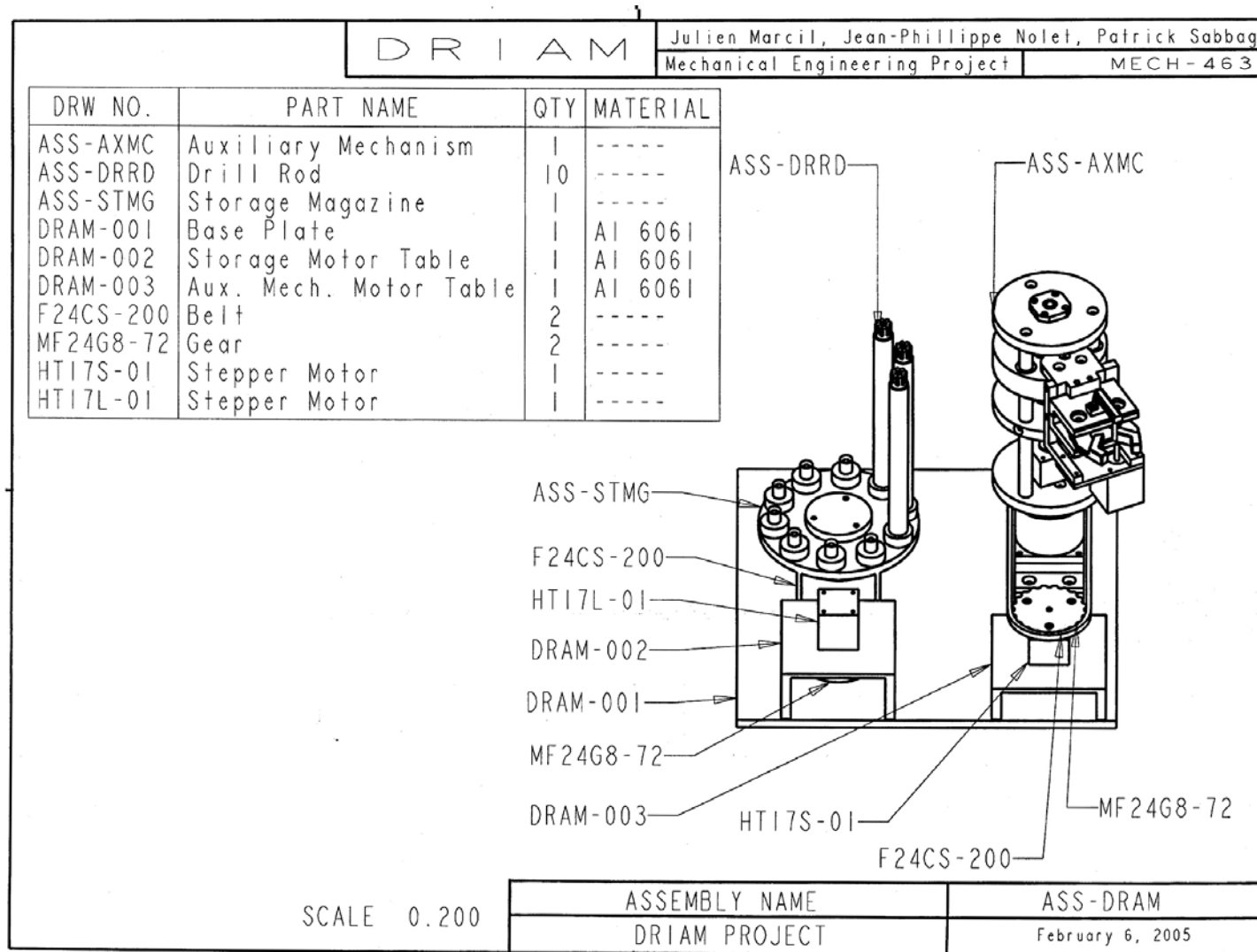


However, you don't have to draw bearings in full detail:
with groove, seals, race, etc.:



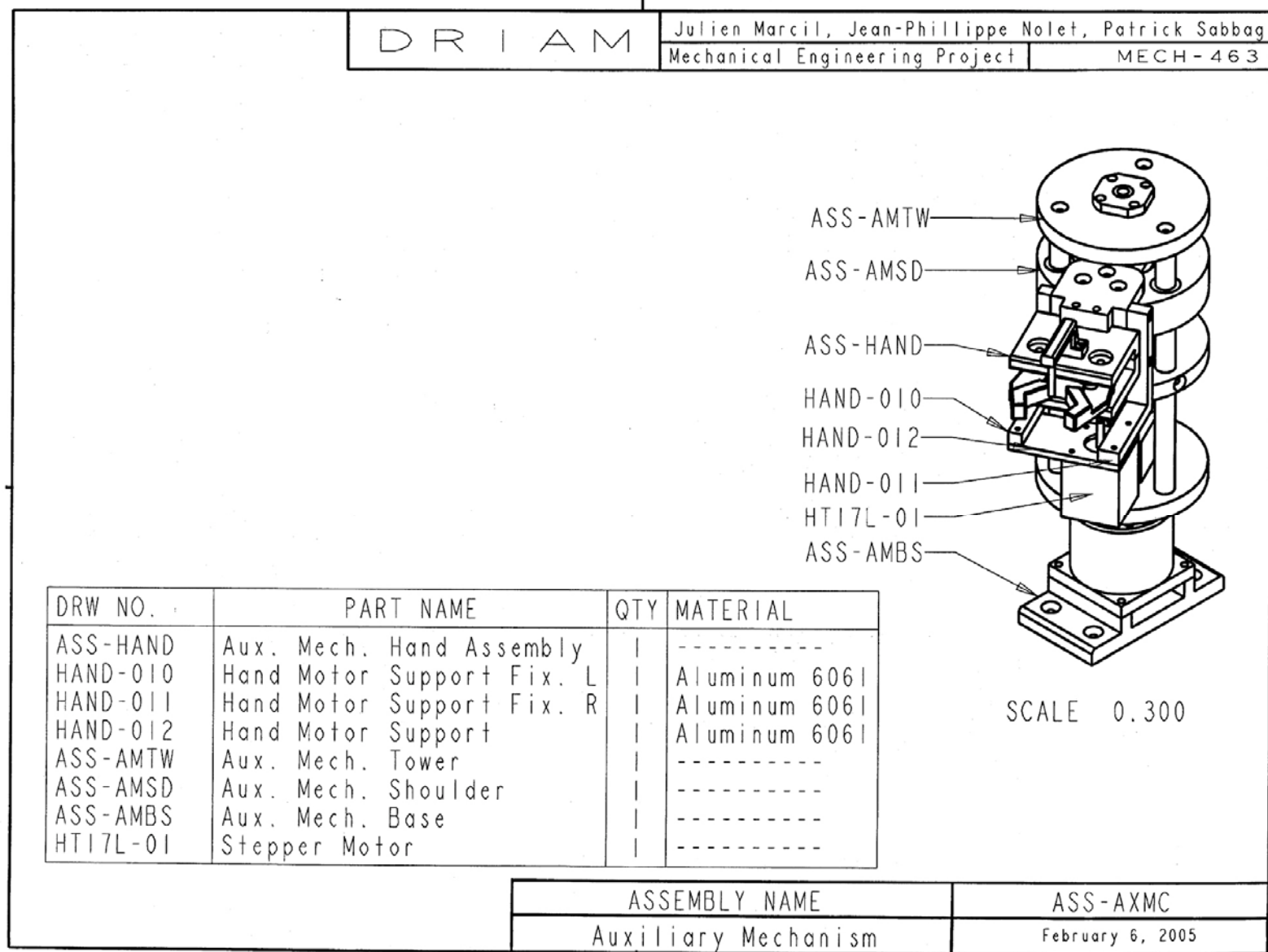
Simplified images are good enough for standard components
in assemblies.

An **assembly drawing** shows how each part of a design is put together. If the design depicted is only part of the total assembly, it is referred to as a **subassembly**.



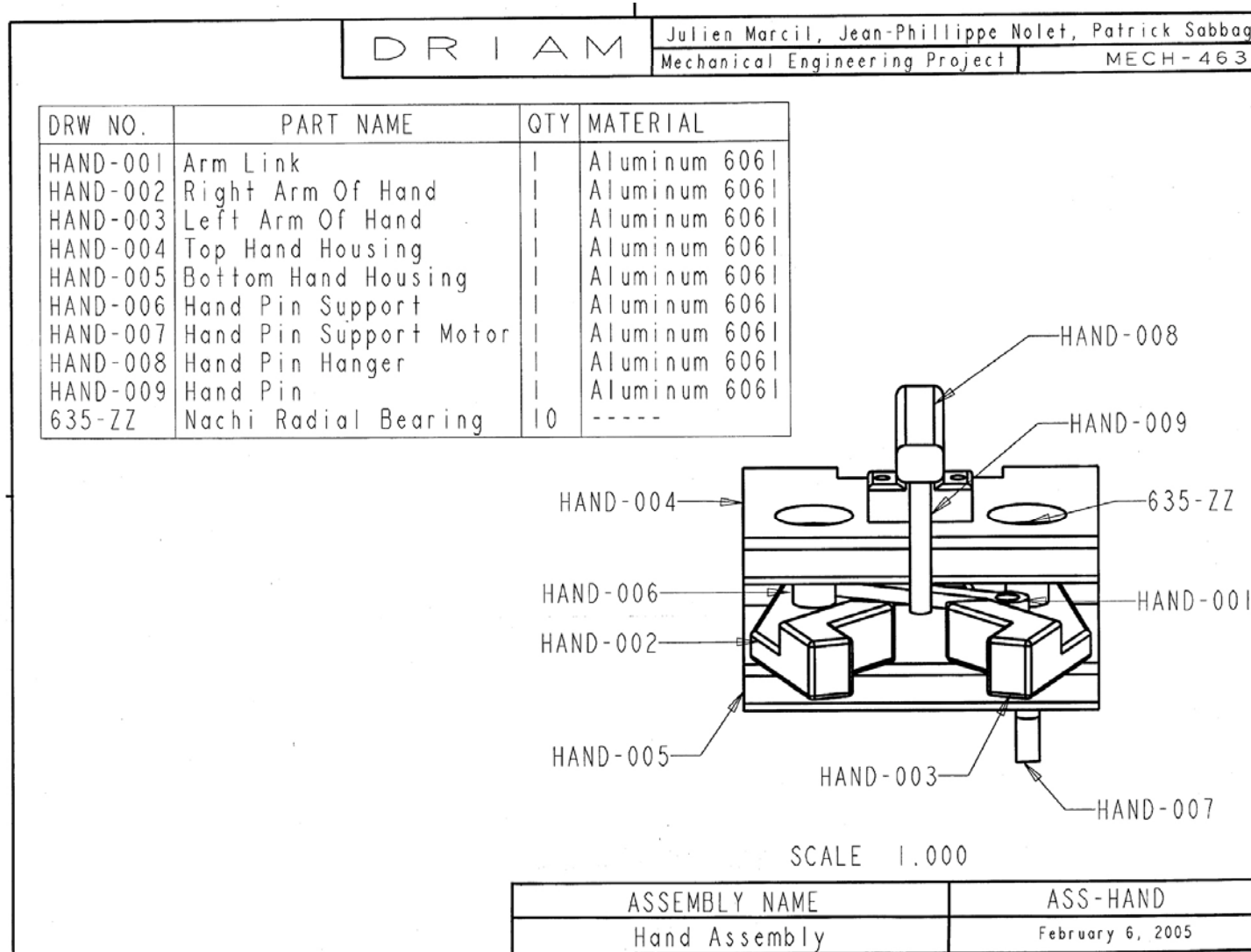
Assembly may consist both of individual original & standard components and of subassemblies of the 1st level.

Subassembly of the 1st level.



1st level subassembly may consist of individual original & standard components and of subassemblies of the 2nd level.

Sub-subassembly, or Subassembly of the 2nd level.

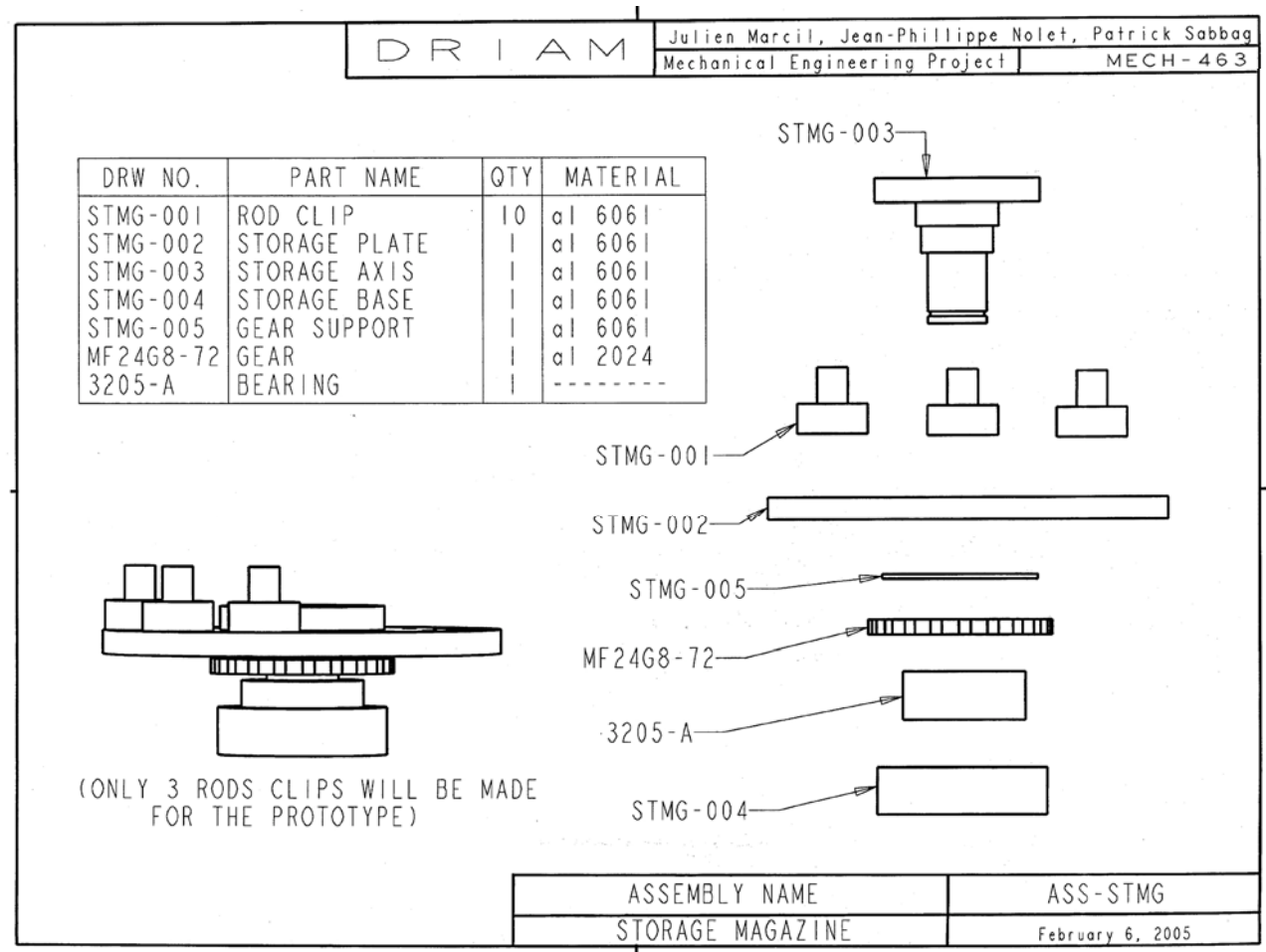


All assemblies and subassemblies should have their own list of components (parts & units). There can be as many levels of subassemblies as needed for the design. Assemblies and subassemblies can be produced in orthographic technique as well as in axonometric view.

Generally, an assembly drawing consists of:

- **All the parts, drawn in their operating position.**
- **A part list or bill of materials (BOM).**
- **Leader lines with balloons, assigning each part a detail number, or just with the name of a part, if the assembly is not too big.**
- **Machining and assembling information and critical dimensions related to these functions.**

(In Figure, the note on the left side view, ONLY 3 RODS CLIPS WILL BE MADE FOR THE PROTOTYPE – information of the engineer about the final product).



Assembly drawings are used to describe how parts are put together as well as the function of the entire unit.

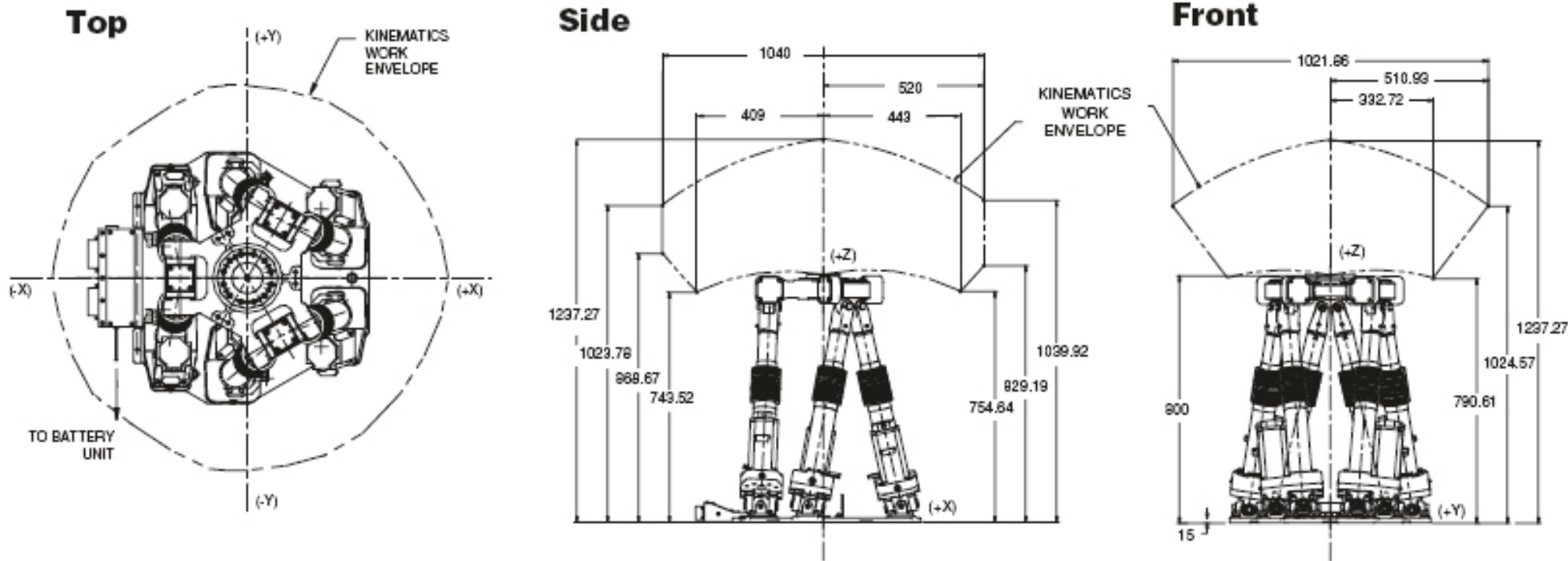
Therefore,

- ✓ complete shape description is not important;
 - ✓ the views chosen should describe the relationships of parts; and
 - ✓ the number of views chosen should be the minimum necessary to describe the assembly (similar to the number of projections needed for a part drawing).
-
- *Dimensions are not shown on assembly drawings unless necessary to provide overall assembly dimensions, or to assist machining operations necessary for assembly.*
 - *Also, hidden lines are omitted in assembly drawings, except when needed for assembly or clarity.*

There are *three basic types of assembly drawings*:

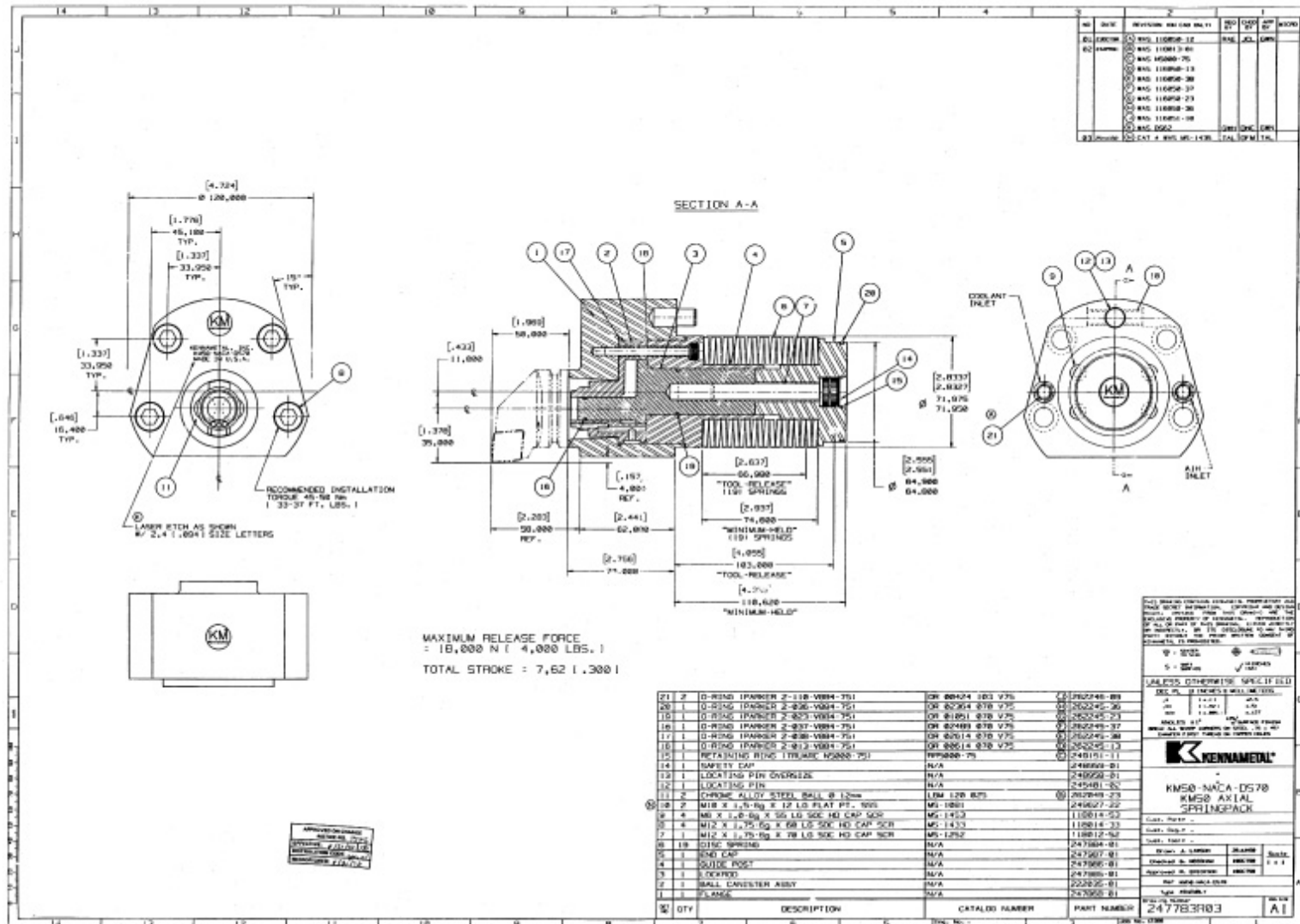
An **outline assembly** gives a *general graphic description of the exterior shape*, as on this outline assembly drawing of a parallel robot:

F-200iB Dimensions



Outline assemblies are used for parts catalogues (general layout of the design) and installation manuals (functionality of the mechanism), or for production when the assembly is simple enough to be visualized without the use of other drawings.

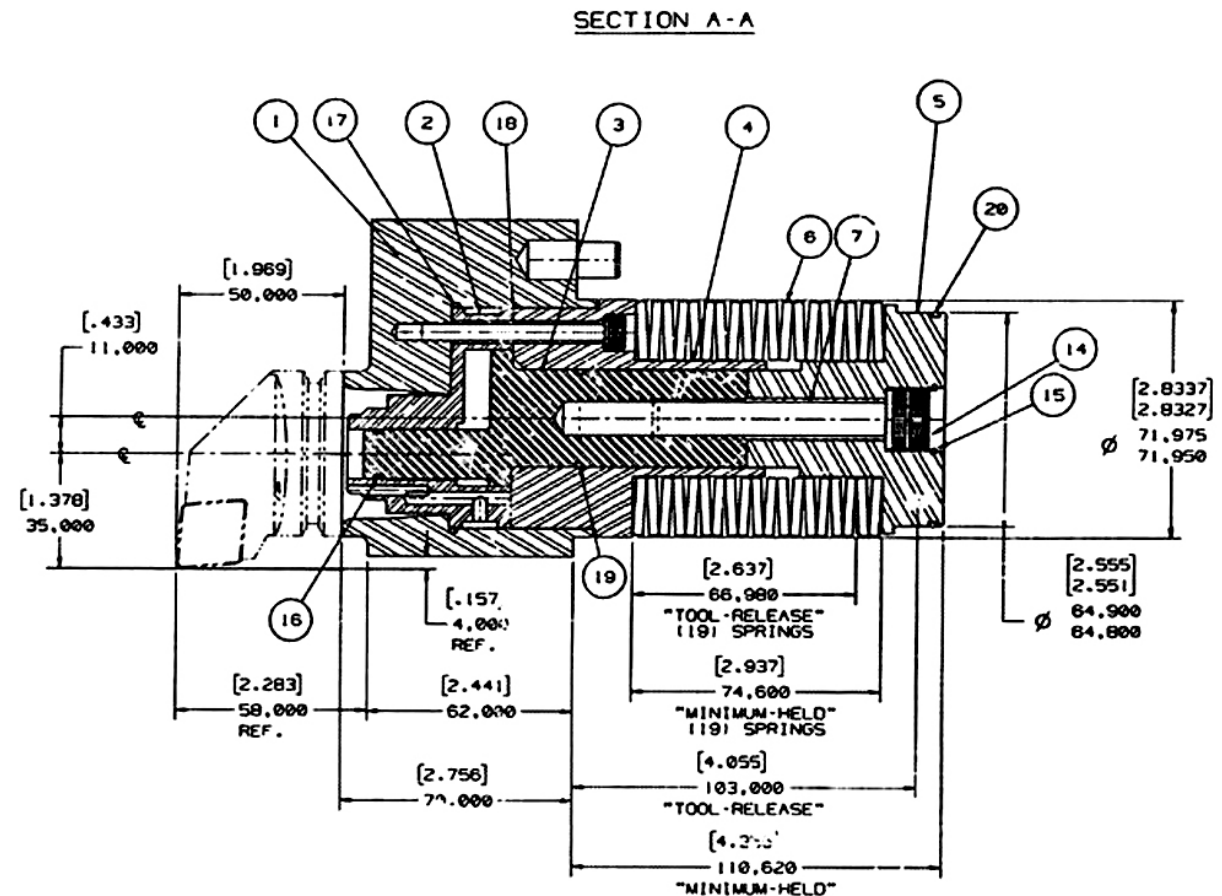
A **sectioned assembly** gives a general graphic description of the interior shape by passing a cutting plane through all or part of the assembly:



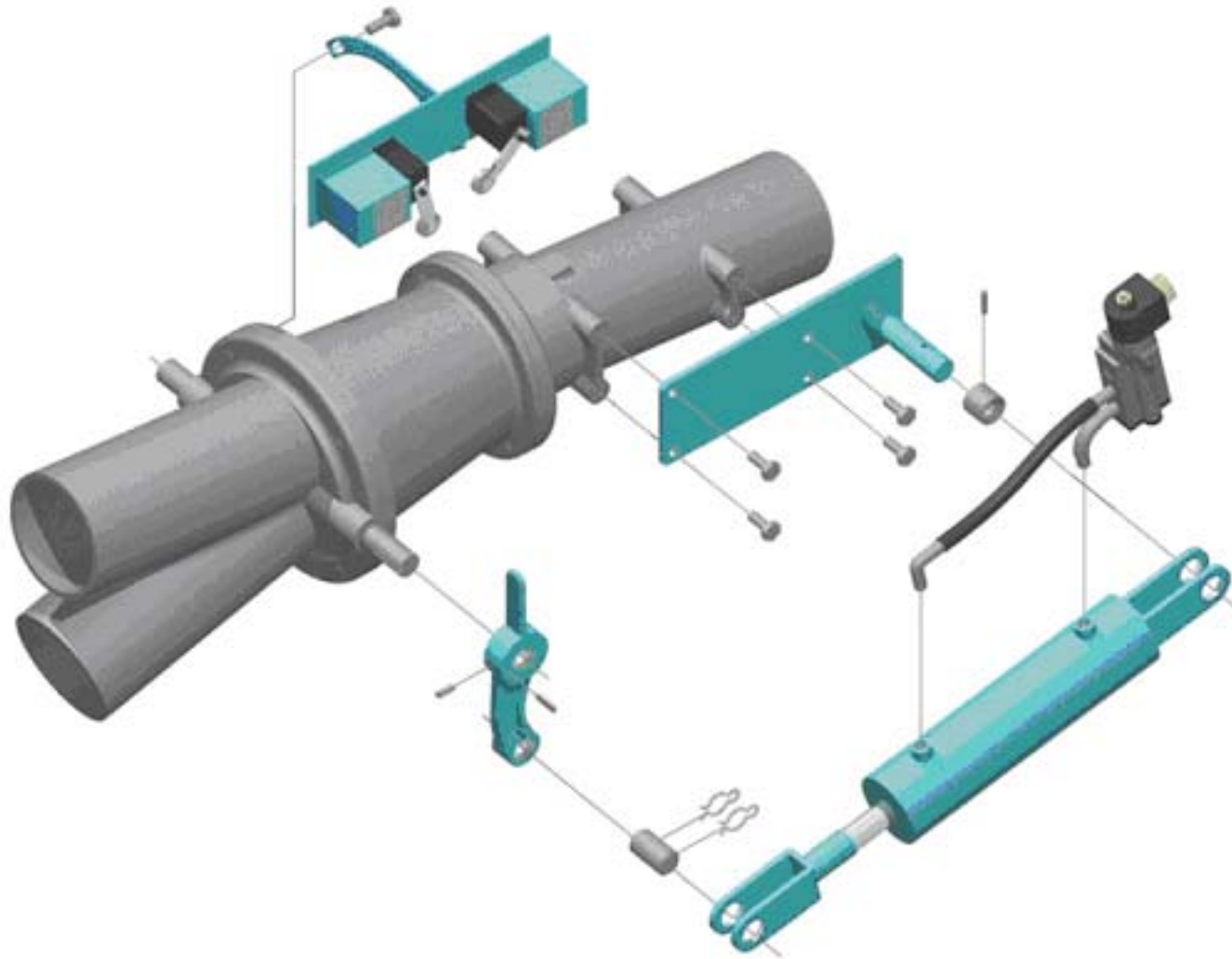
Sectioned assembly drawings are used for manufacturing and assembling complicated devices.

Rules for sectioning assemblies:

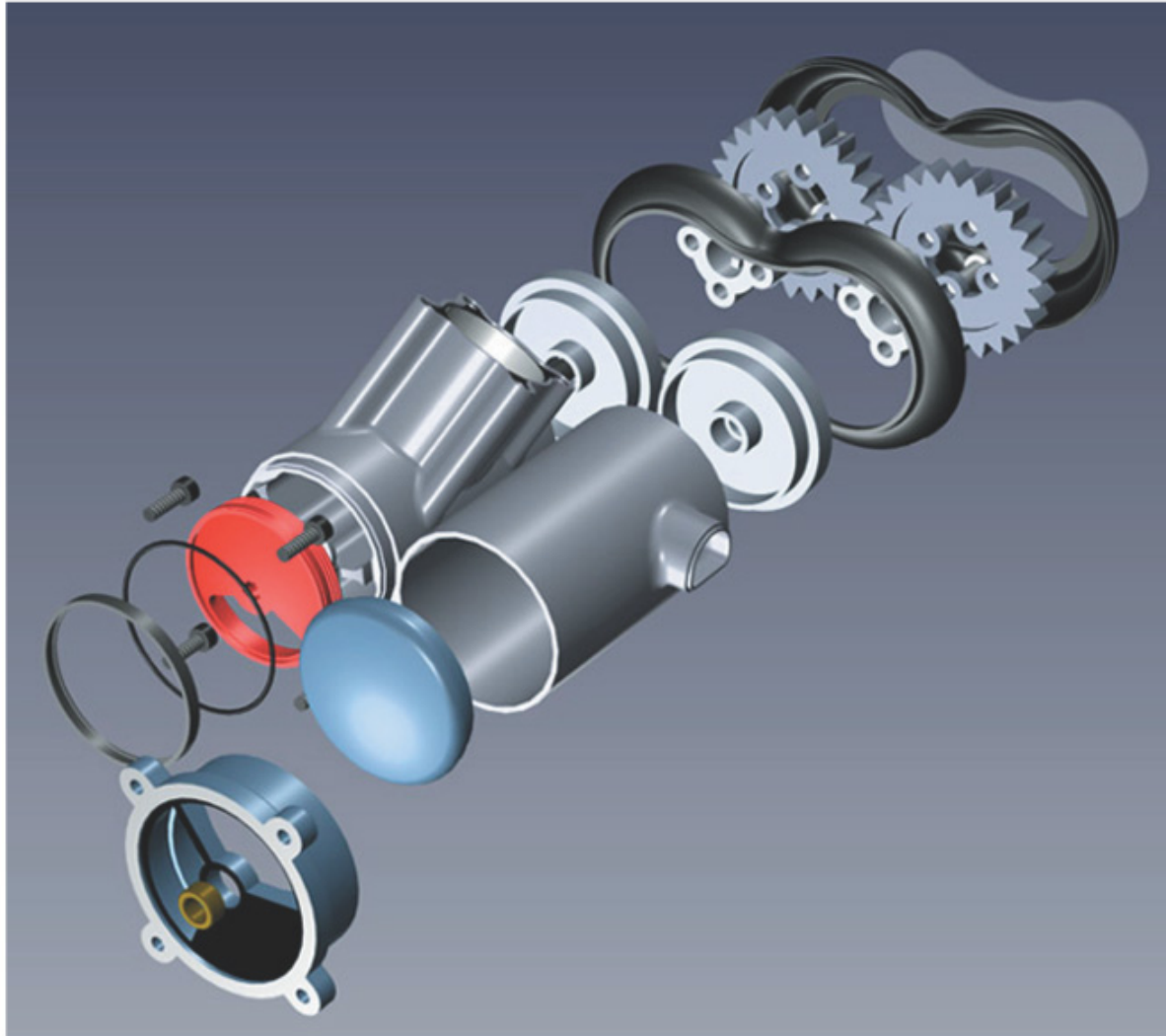
1. Standard parts, such as fasteners, dowels, pins, and gears, and nonstandard parts, such as shafts, are not sectioned. They are drawn showing all their exterior features. (Ex: fasteners – part N 7, socket head cup screw).
Bearings may not be sectioned if the drawing is too crowded.
2. Adjacent parts in section are lined at different angles, using the cast iron or other type of symbol.
3. Thin parts, such as gaskets, are shown solid black. No sectioning is allowed.



A **pictorial assembly** gives a general graphic description of each part, and uses center lines to show how the parts are assembled. A pictorial drawing showing the various parts of an assembly, separated but in proper position and alignment for reassembly, is called an **exploded view**.

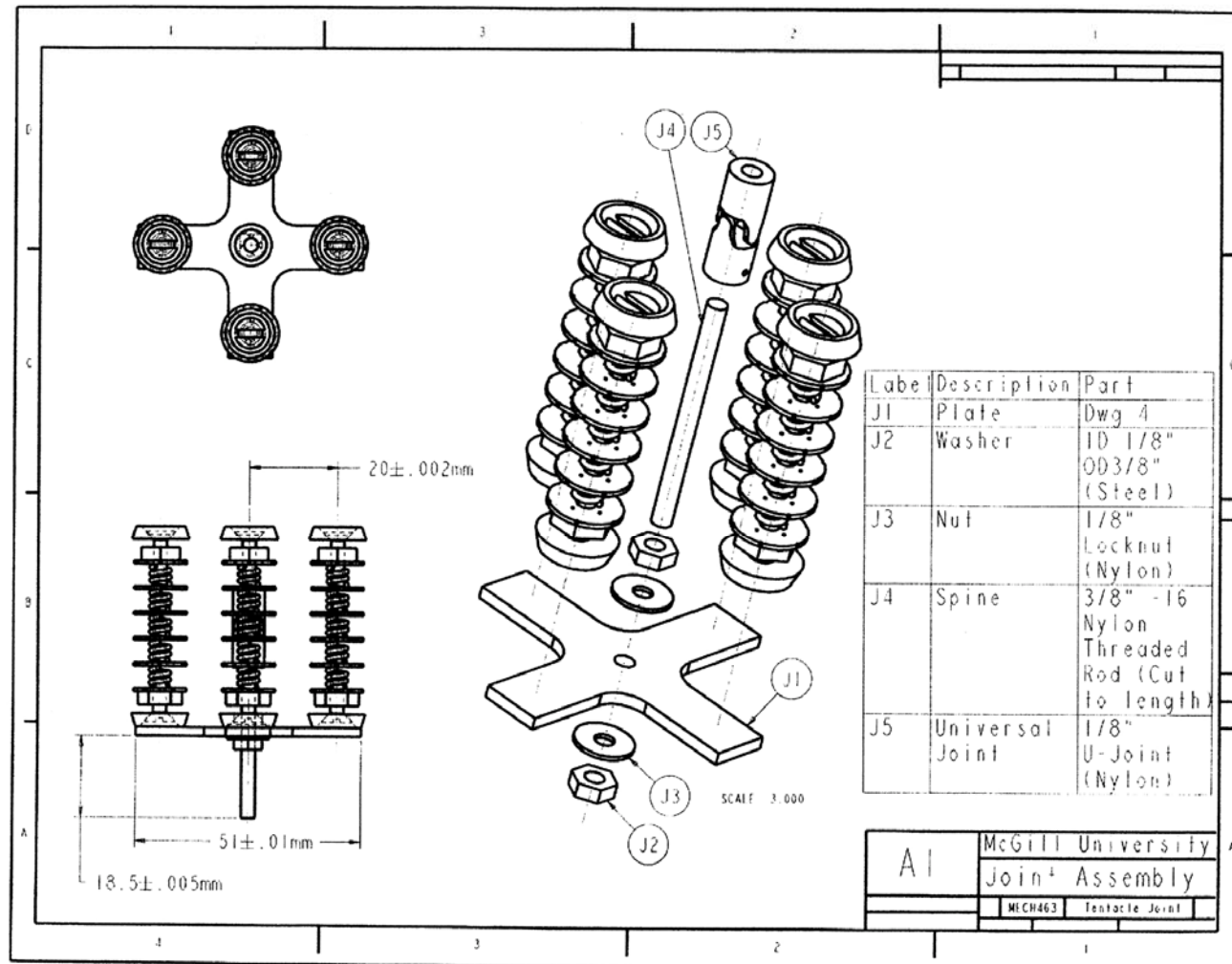


A 3-D CAD model can be used to create pictorial assemblies by positioning each part in a pictorial view.

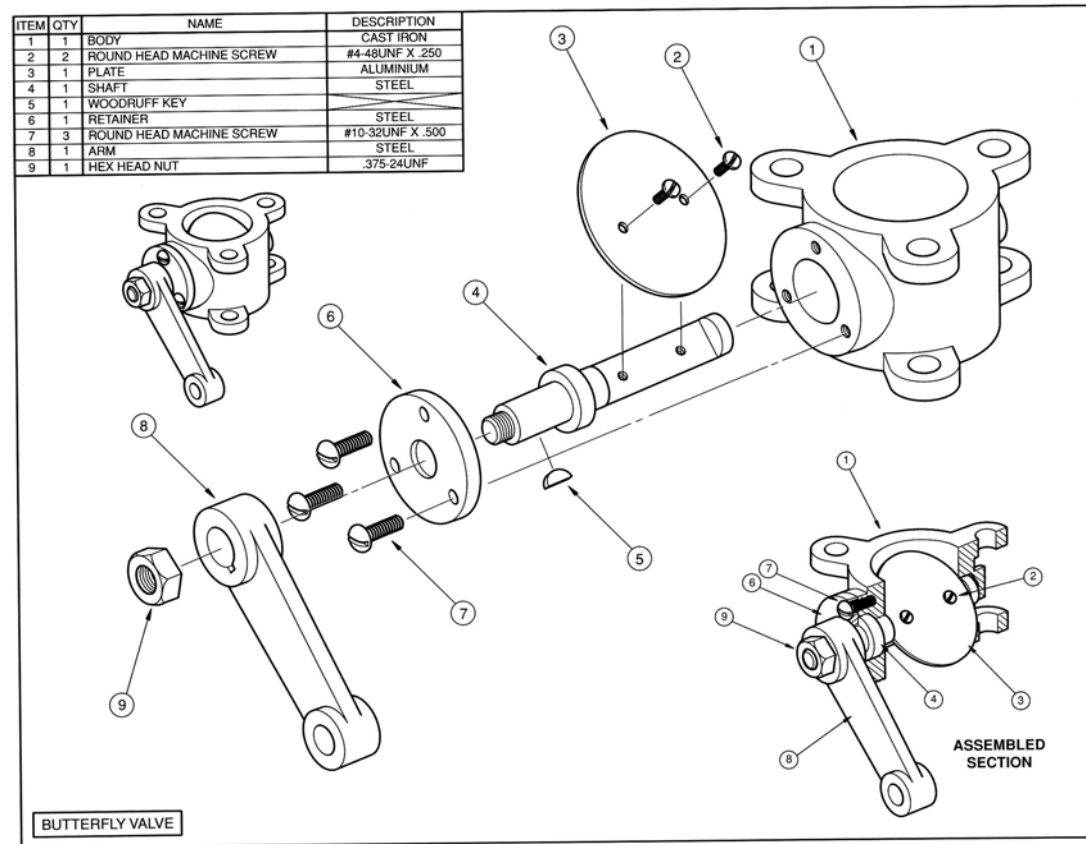


Exploded views are isometric views and are used extensively in service manuals and as an aid in assembling or erecting a machine or structure. Any type of pictorial drawing may be used for this purpose.

The exploded views can be produced not necessarily in the form of solid models. Simple axonometric views are also good for this purpose.

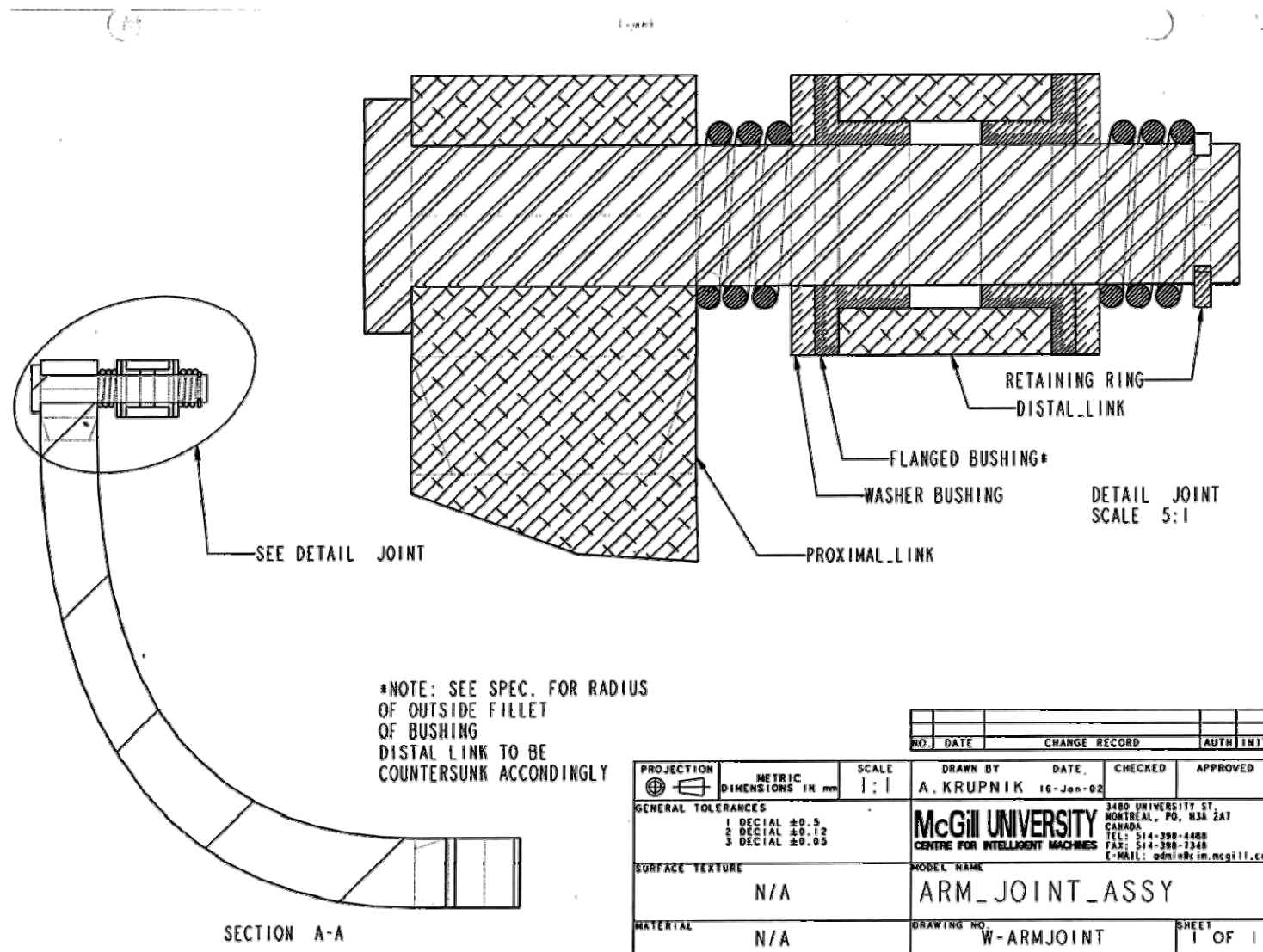


In all types of assembly drawings every part in the assembly is assigned a **part number**, which can be a simple number or a string of numbers coded in such a way that a company can keep accurate records of its products. For example, large aircraft have thousands of parts, and considerable documentation is necessary to design, manufacture, assemble, and maintain the aircraft.



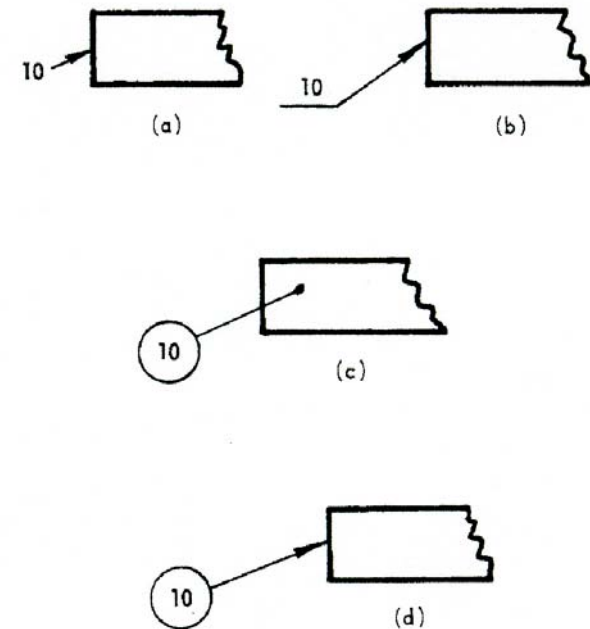
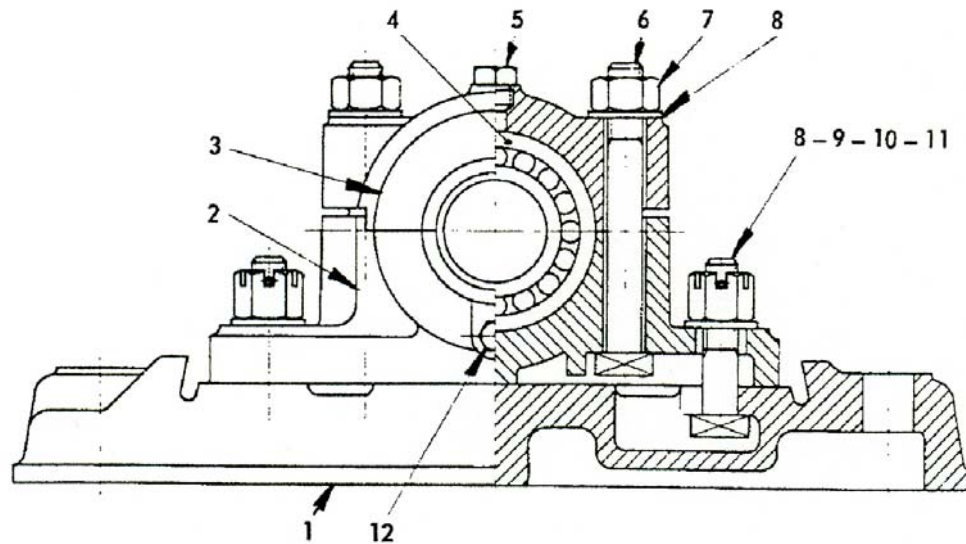
Parts are identified in assembly drawings by a leader line with an arrow that points to the part. The other end of the leader has a **balloon** showing the **part number**. The names of the parts are given in the list of components.

However, if the assembly is simple, it is possible to use part names with the leaders instead of the balloons with numbers.



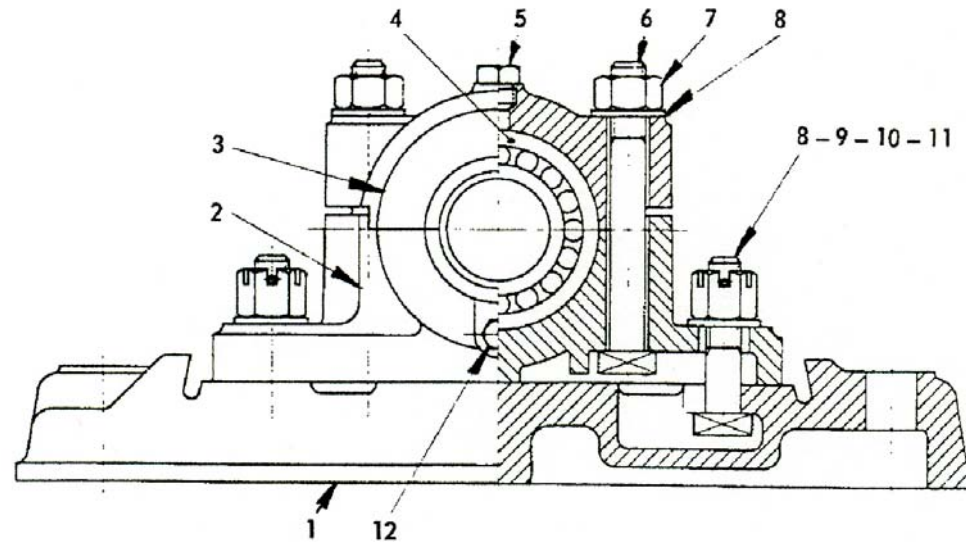
Rules of using leader lines:

- Part numbers should be placed outside the general outlines of the parts concerned.
- Each number should be connected to its associated part by a leader line, the termination of which must comply with the standard (in Canada – CSA Standard CAN3-B78.2, Dimensioning and Tolerancing of Mechanical Engineering Drawings).



- The leader line may be omitted if the relation between the number and its associated part is evident.
- In the case of encircled numbers, the leader line shall be directed towards the centre of the circle.
- Leader lines should not intersect.

- They should be kept as short as practicable and generally they should be drawn at an angle to the part number.
- For the sake of clarity and legibility of the drawing, part numbers should be arranged preferably in vertical columns and/or horizontal rows:



Part numbers of related parts (bolt-nut-washers) may be shown against the same leader line (see items 8, 9, 10 and 11).

A distinct sequence for numbering should be adopted, such as:

- According to the possible order of assembly;
- According to the importance of the component parts (subassemblies, major parts, minor parts, etc.);
- According to any other logical sequence (ex: sequential numbers).

Every drawing used in industry is assigned a number. Each company develops its own standard numbering system, based on various criteria such as

- ❑ sequential numbers,
- ❑ combinations of numbers and letters,
- ❑ sheet sizes,
- ❑ number of parts in the assembly,
- ❑ model numbers,
- ❑ function, etc.

Both **part numbers** and **drawing numbers** are commonly used to name CAD files and code information for companywide CIM databases.

One of the very important concepts of the working drawings is an ***Item (Part) List, or Bill of materials***. A complete set of working drawings must include a detailed parts list or bill of material.

Parts lists or **bill of materials (BOM)** are complete lists of the items constituting an assembly (or a subassembly) of detailed parts, presented on a technical drawing. Such item lists provide necessary information for the production of the items.

Based on ANSI standards, a parts list should be located in the lower right corner above the title block or next to it.



The BOM is divided vertically into columns by means of continuous thick or thin lines to allow the information with regard to the different items to be written in under the following headings (the sequence of these is optional):

- Item – the relevant item reference number as shown on the relevant drawing.
- Name of the part. The “name” column shows the designation of the item. Abbreviations may be used if they do not decrease clarity. If the item describes a standard part (for example, bolt, nut, stud, etc.), its standard designation should be used.
- A detail number for the part in the assembly.
- The part material, for example, cast iron or bronze. This column shows the type and quality of the material to be used. If this is a standard material, its standard designation shall be given, e.g., ASTM A325M.
- The “quantity” – total number of that particular part necessary for one complete assembly.
- The company-assigned part number.
- The drawing number.
- Other information, such as weight, stock size, etc.
- Information on standard parts, such as threaded fasteners, bearings, motors, includes the part name and size or catalog number.
- The “reference” column with different references – particular specifications, related Standards, etc.

Example:

BILL OF MATERIALS

PROJECT: M3 - AGILE WRIST

Date: 21-May-02

SUB-ASSEMBLY	DRW NO.	PART NAME	QTY	MATERIAL	LAST REV
BASE	W-001	BASE_PETAL	1	ALUMINUM 7075-T6	14-Aug-01
MOTOR_I	W-002A	MOTOR_HOUSING_A	3	ALUMINUM 6061-T6	21-May-02
	W-002B	MOTOR_HOUSING_B	3	ALUMINUM 7075-T6	27-Jan-02
	W-003	MOTOR_SHAFT	3	ALUMINUM 7075-T6	21-May-02
	W-007	BRAKE_FLANGE	3	ALUMINUM 6061-T6	22-Aug-01
LINK_I	W-004*	PROXIMAL_LINK	3	ALUMINUM 7075-T6	26-Dec-01
	W-005S	PIN_SHORT	3	STEEL	
	W-005L	PIN_LONG	3	STEEL	
	W-006*	DISTAL_LINK	3	ALUMINUM 7075-T6	26-Dec-01
END_EFFECTOR	W-008	END_EFFECTOR	1	ALUMINUM 6061-T6	14-Aug-01
JIGS	W-J01	CUBE_JIG	1	ALUMINUM	6-Jan-02

NOTE: DRAWING NUMBERS ARE USED IN NAMING OF DRAWING FILES

Drawing file format: PROJE 20

File Location on the CIM network: -atexk/drawings/agilewrist/model_

*Drawing number + J: Process plan drawing.

Unchanged
Maj Rev/New
Dim. Change
Layout Only

Notes: N/A

Bill of Material (BOM) may be divided into sections for different subassemblies if the assembly is too big:

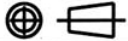
6.1.0 Bill of Material

Project: DRIAM					03-Feb-05
					Date: 05
SUB-ASSEMBLY	DRW NO. / Part Number	PART NAME	QTY	MATERIAL	LAST REV
ASS-DRAM	DRAM-001	Base Plate	1	Aluminum 6061	06-Feb-05
	DRAM-002	Storage Motor Table	1	Aluminum 6061	06-Feb-05
	DRAM-003	Aux. Mech. Motor Table	1	Aluminum 6061	06-Feb-05
	F24CS-200	PIC Design Belt	2	---	06-Feb-05
	MF24G8-72	PIC Design Gear	2	---	06-Feb-05
	HT17S-01	Stepper Motor	1	---	06-Feb-05
	HT17L-01	Stepper Motor	1	---	06-Feb-05
ASS-AMBS	AMBS-001	Base Thrust Bearing Holder	1	Aluminum 6061	03-Feb-05
	AMBS-002	Base Radial Bearing Holder	1	Aluminum 6061	03-Feb-05
	61808-2RS1	SKF Radial Bearing	2	---	03-Feb-05
	81105 TN	SKF Thrust Bearing	1	---	03-Feb-05
ASS-AMTW	AMTW-001	Base Shaft	1	Aluminum 6061	03-Feb-05
	AMTW-002	Base Plate	1	Aluminum 6061	03-Feb-05
	AMTW-003	Mid Plate	1	Aluminum 6061	03-Feb-05
	AMTW-004	Guide	3	Aluminum 6061	03-Feb-05
	AMTW-005	Top Plate	1	Aluminum 6061	03-Feb-05
	MF24G8-72	PIC Design Gear	1	---	03-Feb-05
	HT17S-01	Stepper Motor	1	---	03-Feb-05
	TS 1404+500L	THK Ball Screw Shaft	1	---	03-Feb-05
	FF10	THK Free Support	1	---	03-Feb-05
	FK10	THK Fixed Support	1	---	03-Feb-05
ASS-AMSD	MTSD-001	Aux. Mech. Shoulder	1	Aluminum 6061	03-Feb-05
	MTSD-002	Aux. Mech. Arm	1	Aluminum 6061	03-Feb-05
	LBBR 14	SKF Linear Bearing	3	---	03-Feb-05
	BTK 1404-3.6ZZ	THK Ball Screw Nut	1	---	06-Feb-05

Title blocks are used to record all the important information necessary for the working drawings. The title block is normally located in the lower right corner of the drawing sheet.

From the 1st lecture we know that title blocks should contain the following:

- Name and address of the company or design activity.
- Title of the drawing.
- Drawing number.

2		21/5/02	dia & length of rotor mount.			AK
1		21/5/02	width of bearing space			AK
NO.	DATE	CHANGE RECORD			AUTH	INIT
PROJECTION 		ENGLISH DIMS. IN INCHES 13:10		DRAWN BY A. KRUPNIK	DATE 14-Aug-01	CHECKED
GENERAL TOLERANCES 1 DECIMAL ± 0.1 2 DECIMAL ± 0.01 3 DECIMAL ± 0.001				McGill UNIVERSITY CENTRE FOR INTELLIGENT MACHINES 3480 UNIVERSITY ST. MONTREAL, PQ, H3A 2A7 CANADA TEL: 514-398-6313 FAX: 514-398-7348 E-MAIL: admin@cim.mcgill.ca		
SURFACE TEXTURE N6				MODEL NAME MOTOR_SHAFT		
MATERIAL ALUMINUM 6061-T6				DRAWING NO. W-003-0A		SHEET 1 OF 1

- Names and dates of the drafters, checker, issue date, contract number, etc.
- General tolerances.
- Units.
- Predominant drawing scale.
- Material of the part.
- Type of projections.
- Sheet number, if there are multiple sheets in the set.

The designations METRIC or SI appear in or near the title block to show that metric dimensions and scale are used on the drawing. Tolerances are specified in a drawing using toleranced dimensions. For those dimensions that are not specifically toleranced, a **general tolerance note** is used.

Revision Blocks

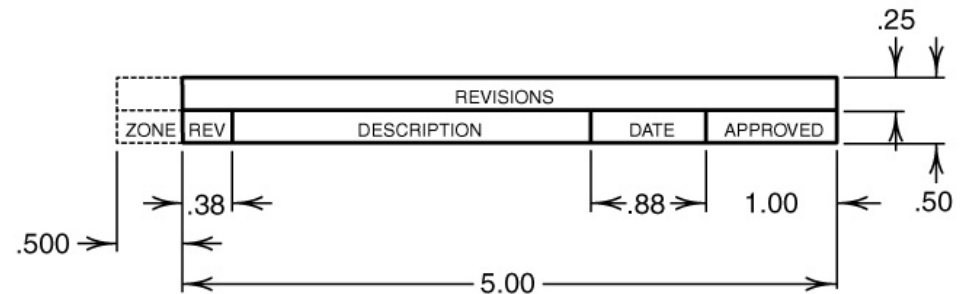
Drawing revisions occur because of design changes, tooling changes, customer requests, errors, etc.

When a drawing is revised because of design changes, errors, etc., an accurate record of the change should be created.

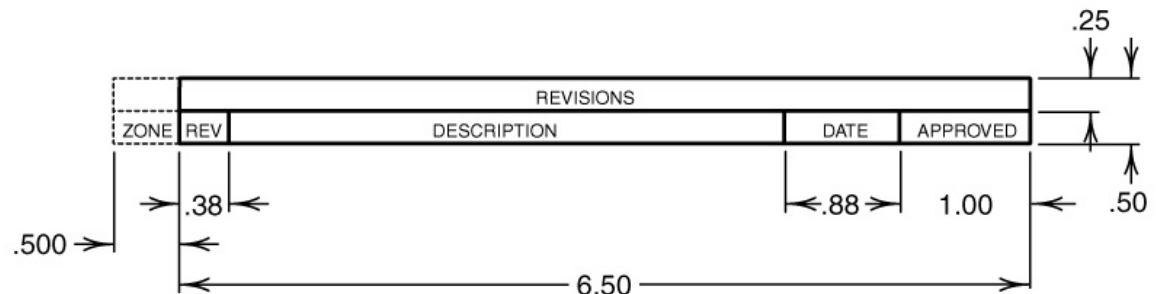
This information includes:

- The date
- Name of the person making the change
- Description of the change
- The change number
- Placement zone on the drawing
- Approval for the change, etc.

This information is placed in a **revision block** which is normally located in the upper right corner of the drawing, or above the bottom line of the drawing area, on the left from the title block.



Revision block for A, B, C, and G - sizes



Revision block for D, E, F, H, J, and K - sizes