University of Nottingham
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MMME2044 Individual Design

Gearbox Actuator

Clinic session for CDR

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Observation from PDR submission

Where you’re doing well

- Good understanding of requirements (SoR)
- Concept generation and selection using morphology chart and decision matrix table
- Calculation of power, torque and forces, etc
- Embodiment design from some submissions

Where improvement may be made

- Detailed calculations for spring selection and actuator sizing
- Embodiment and detail design so as to start Solidworks modelling and GA/detail drawings

Outline of session

The purpose of the CDR clinic session is

- to discuss and clarify questions from PDR submission
- to give an outline for CDR submission
- to show examples on design and calculations
- to recap a few points, e.g. GA and detail drawings
- to remind a few items for productive working toward CDR submission

Critical Design Review (CDR)

The CDR submission is to present

- a satisfactory design solution to meet stated requirements,
- a complete record/documentation of the project to date.

The **CDR report** should be presented using the provided **CDR pro-forma**

- ➢ Executive summary (1 page, max 300 words)
- ➢ Engineering and design rationale (including updated Statement of Requirements and Morphology chart using pro-forma) (2~3 pages)
- ➢ Materials selection (1~2 pages)
- ➢ Calculations (2~4 pages)
- ➢ GA (General Arrangement) drawings (one the Actuator alone and the other showing the Actuator assembled onto the Gearbox) (2 pages)
- ➢ Detail drawings of Actuator casing and actuating shaft (piston rod) (2 pages)
- ➢ Time management (using Student Guidelines pro-forma) (1 page)
- ➢ Appendices (optional)

Note: It is useful to refer to Project Brief file.

Individual Design CDR submission on Moodle

- The deadline for CDR submission on **Moodle is 3:00pm, Friday, 31st March**.
- The CDR report is a **Summative submission**. It is worth **30% of the MMME 2044 module**.
- The **CDR pro-forma and template folders/files** will be available in the Individual **Design Project folder** in the **Design Tutorial and Feedback section** on Moodle.
- Make sure your **CDR report** (a single file in PDF format) is compiled in **a clear and concise manner** to recommended pages.
- Place your CDR report, spreadsheet/hand-written files and Solidworks models and drawings in separate folders **as from the template folder**.

Preparation of CDR report

Executive summary (1 page per group, 300 words max)

- Give a CONCISE summary of your individual design solution of the Gearbox Actuator,
  - A summary of the actuator design if it meets all requirements
  - A very brief discussion on specific features for proper function and considerations for easy manufacturing, assembly and operation

Table of content (optional)

Preparation of CDR report

Engineering and Design Rationale (2~3 pages max)

- Present an **updated statement of requirements** using pro-forma.
- Present your **rationale and assessment** to the following questions:
  - How does the Actuator work?
  - Are all design requirements met?

    An updated morphology chart showing how the **Final Design meets requirements**
  - What are the strengths and weaknesses of the design?
  - Can the design be easily manufactured, assembled and operated in all possible operational conditions?

Preparation of CDR report

Engineering and Design Rationale (cont'd)

- You may use Solidworks assembly **images and/or cutaway views** to identify key parts and design features and to describe how the air motor operates for the intended functions.

B-4 Interfaces:

Interfaces were created to accommodate the ancillary devices onto the engine block. This allows for easy assembly and attachment. The following figures show two isometric views of the engine block, which shows the interfaces.

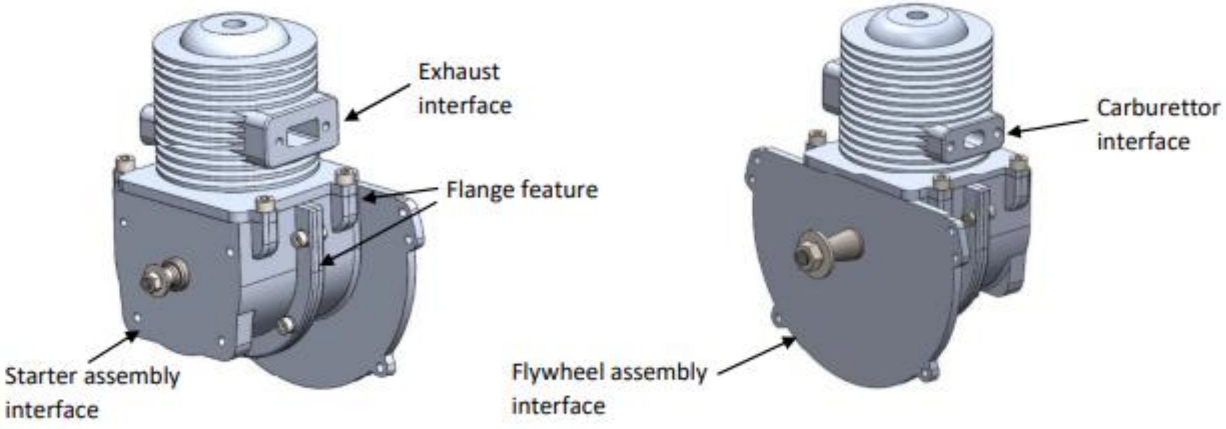


Figure 3: Two isometric views of the engine block showing the interfaces

B-3 Mounting of the cylinder/crankcase

To ensure proper alignment of the piston head to the crankcase, a circular sleeve feature has been added which provides proper mounting which fits into the crankcase.a flange feature has been embodied in the design and 4 M5 bolths will be used to connect the cylinder heaad to the crankcase.The following figure is a cross section of the engine block showing all of the designed components along with the mounting of the bearings.

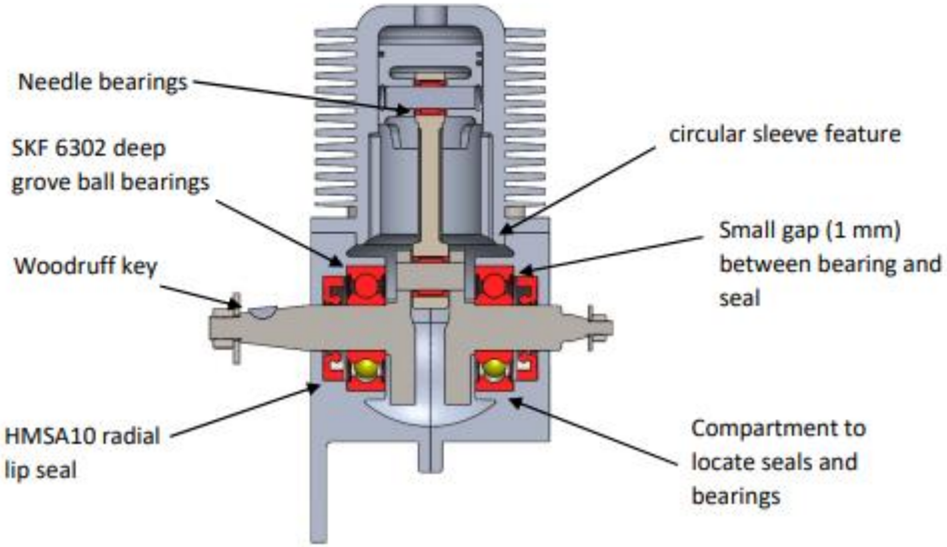


Figure 2: cross section of the engine block, showig the layout of the engine components.

An example of individual design: 2-stroke engine (available on Moodle)

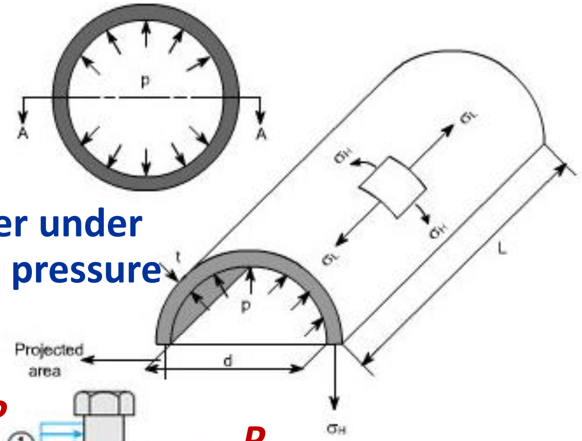
Preparation of CDR report

Need update!!!

Calculations (2~4 pages)

- **Sumarise calculation results supported by spreadsheet with clear annotations in the template folder** (**see spreadsheet of ASME shaft design on Moodle**)
  - Updated spring calculations (**see Lecture slides for preparing PDR**)
  - Stress calculation of the cylinder and other parts under severe loading
  - Bolted joints and tightening torque
  - Selection of seals
- **Circumferential and longitudinal stresses of a hydraulic cylinder (thin-walled vessel as from MMME1028)**
  - **Hoop (circumferential) stress:** $\sigma_\theta = \frac{pr}{t}$
  - **Longitudinal (axial) stress:** $\sigma_L = \frac{pr}{2t}$

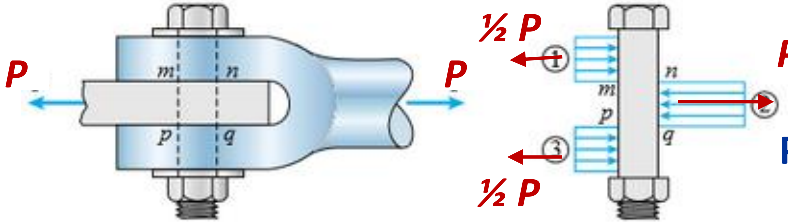
p - pressure
r - inner radius
t - thickness



Cylinder under internal pressure

- **Pin or bolt under double shear loading**
  - **Shear stress:** $\tau = \frac{1}{2}\frac{P}{A}, A = \frac{\pi}{4}d^2$

P - force
d - diameter



Pin/bolt under double shear

Preparation of CDR report

- **Calculations**
  - **Reserve factors** (also called Safety factor)

1) Understand loading condition of key parts and decide initial dimensions;
2) **Calculate** axial or shear force, torque or bending moment;
3) **Select** a suitable material/heat treatment and **find material properties**, e.g. yield strength (**σ_Y**), endurance limit stress (**σ_e**);
4) **Calculate max stresses**, e.g. max stress (**σ_{max}**) under tension or bending, or max shear stress (**τ_{max}**) due to torsion or direct shear;
5) **Calculate** the **reserve factor**, $n_{rf} = \sigma_Y$ or $\sigma_e / \sigma_{max} \geq 1$ or $n_{rf} = \tau_Y$ or $\tau_e / \tau_{max} \geq 1$ or a given value; if not, go back to **2)** or **4)** and iterate until an optimum solution obtained.

- **Tresca (max shear) yield criterion :** $\tau_y = \frac{1}{2}\sigma_y$
- **von Mises (max strain energy) yield criterion:** $\tau_y = \frac{1}{\sqrt{3}}\sigma_y = 0.577\sigma_y$

τ_y **is shear stress at yielding** and σ_y **is tensile yield strength** **(same Eqs apply to endurance limits)**

Worked example: Joint design for a 2-stroke engine

(A worked example from Bolted joints Lecture slides 49~52)

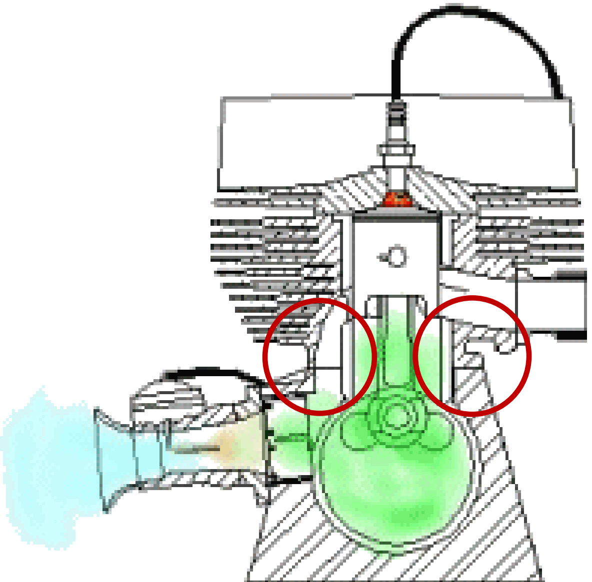
- **Design bolted joint for the cylinder & casing of a** 2-stroke engine.
  - Peak force is ***P* = 6.5 kN**
  - A **permanent joint** with a threaded grip length l_t **= 25 mm**
  - Cylinder and crankcase are made of cast Al (**E=70 GPa**)
  - **4 x bolts (5.6 or similar,** carbon steel, **E=200 GPa)**
  - **Reserve factor** should be at least **1.5**.
- **Determine**

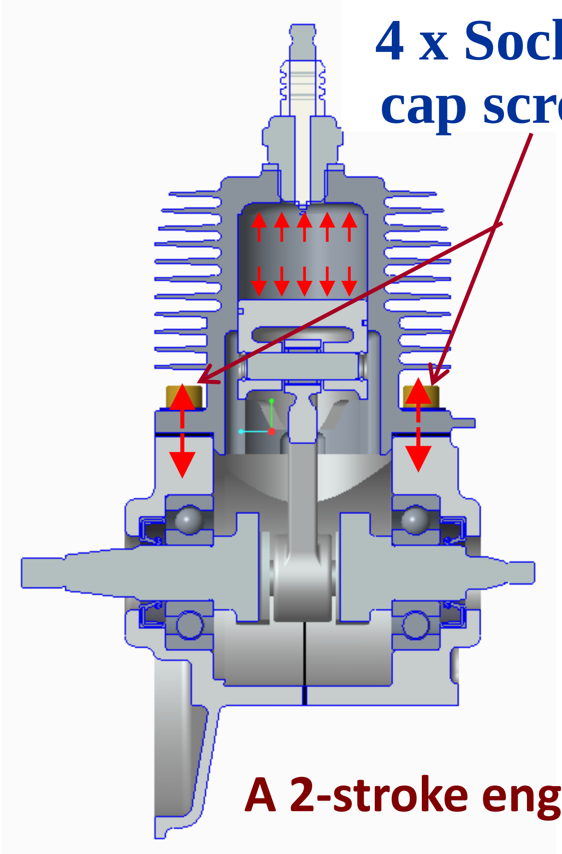
a) Suitable size of socket cap screw

b) Right amount of tightening torque

Otto cycle of two-stroke engine

https://en.wikipedia.org/wiki/Two-stroke_engine





A 2-stroke engine

Worked example: Joint selection of a 2-stroke engine

a) Selection of a suitable socket cap screw

Bolted joint Part 3

1. **Joint design** specifies external load (***P=6.5 kN***) and reserve factor (***n_o=1.5~2***), a **permanent joint** of **4 x** socket cap screw (***N=4***).

2. **Choose** a suitable bolt size from **BS ISO 898-1: 2009 (Table 5)**

Select M4 and a property class of 5.6,

For a non-permanent joint, $F_i = 0.75 \times A_S\, \sigma_p$

For a permanent joint, $F_i = 0.9 \times A_S\, \sigma_p$

As no maintenance required,

$$F_i = 0.9 \times A_S \sigma_P = 0.9 \times F_P$$
$$= 0.9 \times 2,460 = 2,214(N)$$

Table 5 — Proof loads — ISO metric coarse pitch thread

Thread[a] d	Nominal stress area $A_{s,nom}$[b] mm²	Property class 4.6	4.8	5.6	5.8	6.8	8.8	9.8
		Proof load, F_p ($A_{s,nom} \times S_{p,nom}$), N						
M3	5,03	1 130	1 560	1 410	1 910	2 210	2 920	3 270
M3,5	6,78	1 530	2 100	1 900	2 580	2 980	3 940	4 410
M4	8,78	1 980	2 720	2 460	3 340	3 860	5 100	5 710
M5	14,2	3 200	4 400	3 980	5 400	6 250	8 230	9 230
M6	20,1	4 520	6 230	5 630	7 640	8 840	11 600	13 100
M7	28,9	6 500	8 960	8 090	11 000	12 700	16 800	18 800

Worked example: Joint selection of a 2-stroke engine

Bolted joint Part 3

3. **Calculate** stiffness of the **bolts & components** (***Kb*** & ***Kc***):

$$K_b = \frac{A_S E}{l_t} = \frac{8.78 \times 200 \times 10^3}{25} = \mathbf{70.2 \times 10^3} (N/mm)$$

Assume a "hard joint", i.e. ***Kc = 3 Kb,*** so, $K_c = 3 \times K_b = \mathbf{210.6 \times 10^3} (N/mm)$

Note: The same approach may be used in the **Gearbox Actuator calculations**.

4. **Calculate** max external load (***Po***) without separation **(Bolted joints Lecture slide 39):**

$$P_0 = NF_i \frac{K_b + K_c}{K_c} = 4 \times 2{,}214 \times \frac{(70.2 + 211.3) \times 10^3}{211.3 \times 10^3} = \mathbf{11,790} (N)$$

5. **Calculate** the **Reserve factor** (***no***):

$$n_0 = \frac{P_0}{P} = \frac{11{,}790}{6{,}500} = \mathbf{1.8 > 1.5}$$

Therefore, 4x M4 (5.6) screws are acceptable.

If not, either choose M5 cap screw or higher grade, e.g. 5.8, 6.8, 9.8

6. **Tightening torque (Bolted joints Lecture slide 27):**

$$T = kF_i d = 0.2 \times 2{,}214 \times 0.004 = \mathbf{1.8}\ (Nm)$$

K* ≈ 0.2**; ***Fi is pre-tension force (N), ***d*** is diameter (m)

Note: Above Eq. is a simplification of the **power screw formula** from Dr Johnson's lecture in MMME1024.

Metric thread tensile area and mechanical properties

Bolted joint Part 2

- **BS EN ISO 898-1: 2013 Mechanical properties of fasteners made of carbon and alloy steels** (Bolted joint Lecture slide 11)

Thread nominal dia, *d*

Tensile area, *As* (mm^2)

Thread property grade, (X.Y)

Proof load *Fp=As x σp* (N)

Table 5 — Proof loads — ISO metric coarse pitch thread

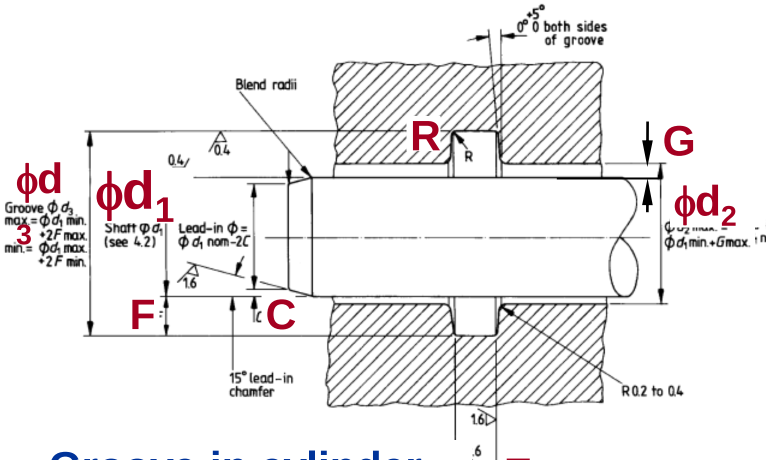
Thread [a] d	Nominal stress area $A_{s,nom}$ [b] mm^2	Property class								
		4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9/<u>12.9</u>
		Proof load, F_p ($A_{s,nom} \times S_{p,nom}$), N								
M3	5,03	1 130	1 560	1 410	1 910	2 210	2 920	3 270	4 180	4 880
M3,5	6,78	1 530	2 100	1 900	2 580	2 980	3 940	4 410	5 630	6 580
M4	8,78	1 980	2 720	2 460	3 340	3 860	5 100	5 710	7 290	8 520
M5	14,2	3 200	4 400	3 980	5 400	6 250	8 230	9 230	11 800	13 800
M6	20,1	4 520	6 230	5 630	7 640	8 840	11 600	13 100	16 700	19 500
M7	28,9	6 500	8 960	8 090	11 000	12 700	16 800	18 800	24 000	28 000
M8	36,6	8 240 [c]	11 400	10 200 [c]	13 900	16 100	21 200 [c]	23 800	30 400 [c]	35 500
M10	58	13 000 [c]	18 000	16 200 [c]	22 000	25 500	33 700 [c]	37 700	48 100 [c]	56 300
M12	84,3	19 000	26 100	23 600	32 000	37 100	48 900 [d]	54 800	70 000	81 800
M14	115	25 900	35 600	32 200	43 700	50 600	66 700 [d]	74 800	95 500	112 000
M16	157	35 300	48 700	44 000	59 700	69 100	91 000 [d]	102 000	130 000	152 000
M18	192	43 200	59 500	53 800	73 000	84 500	115 000	—	159 000	186 000
M20	245	55 100	76 000	68 600	93 100	108 000	147 000	—	203 000	238 000
M22	303	68 200	93 900	84 800	115 000	133 000	182 000	—	252 000	294 000
M24	353	79 400	109 000	98 800	134 000	155 000	212 000	—	293 000	342 000

Worked example: “O” ring selection for Air motor piston

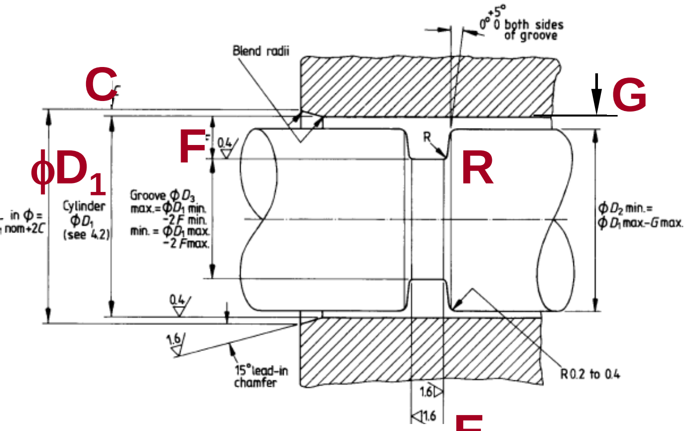
Select suitable “O” rings & Groove dimensions (based on **BS 4518**)

Refer Seals Lecture slides & worked examples to select an “O” ring. You may also use **James Walker** and **ClaronPolysea® catalogues** available on **Moodle** to select suitable seals.

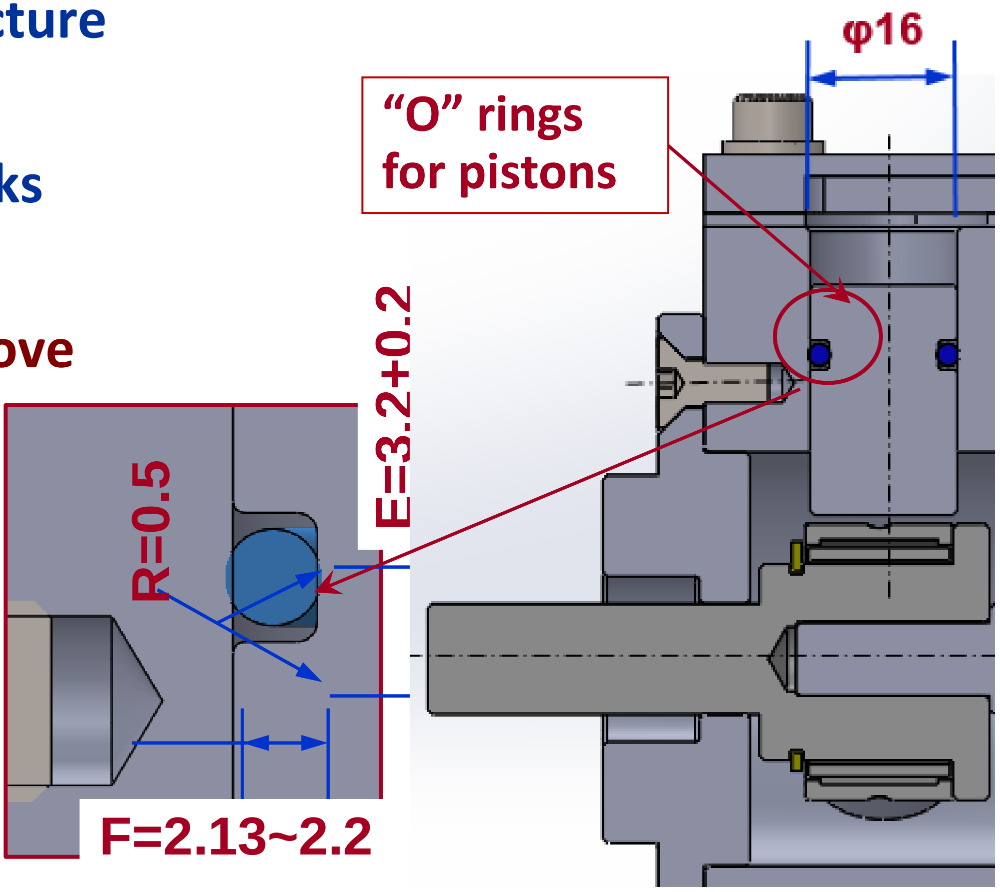
- **“O” ring grooves** cut in piston (shaft).
- From **BS4518 Table 1** (available on **Moodle and Seals Lecture handbook**), **0116-24** is suitable for a **ϕ16 mm piston.**
- **0116-24 “O” rings CAD model** is available from **Solidworks Toobox BSI part library** or you can create yourself.
- From **BS4518 Table 4, 0116-24** “O” ring should have **Groove dimensions below**.



Groove in cylinder

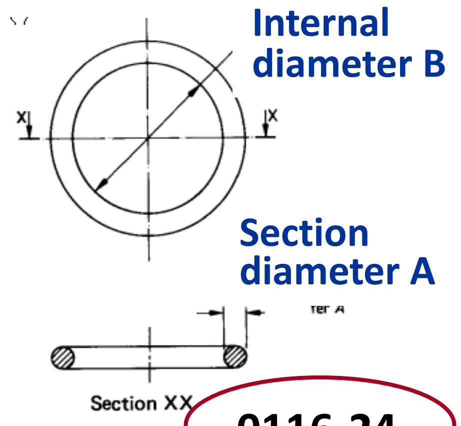


Groove in piston



Worked example: “O” ring selection for Air motor piston

Select a suitable “O” ring Groove dimensions (Groove in piston)



0116-24

B = ϕ 11.6 mm
A = ϕ 2.4 mm

Table 1 — Dimensions of “O”-rings (see Figure 1) and related nominal housing diameters for diametral sealing (see Figure 2)

All dimensions in millimetres

“O”-ring ref. no (see note)	“O”-ring dimensions				Nominal housing dimensions (see Figure 2 and 4.1)	
	Internal diameter B	Internal diameter tolerance	Section diameter A	Section diameter tolerance	Shaft diameter d_1	Cylinder diameter D_1
0031-16	3.1		1.6		3.5	6
0041-16	4.1		1.6		4.5	7
0096-24[a]	9.6		2.4		10[b]	14
0106-24[a]	10.6		2.4		11	15
0116-24[a]	11.6		2.4		12[b]	16[b]
0126-24[a]	12.6		2.4		13	17
0136-24[a]	13.6	± 0.2	2.4	± 0.08	14[b]	18

“O” ring groove dimensions

Depth **F** = 2.13~2.20

Width **E** = 3.2+0.2

Clearance **Gmax** = 0.14

Chamfer **C** = 0.6

Radius **R** = 0.5

Table 4 Groove Dimensions for pneumatic applications

All dimensions in millimetres

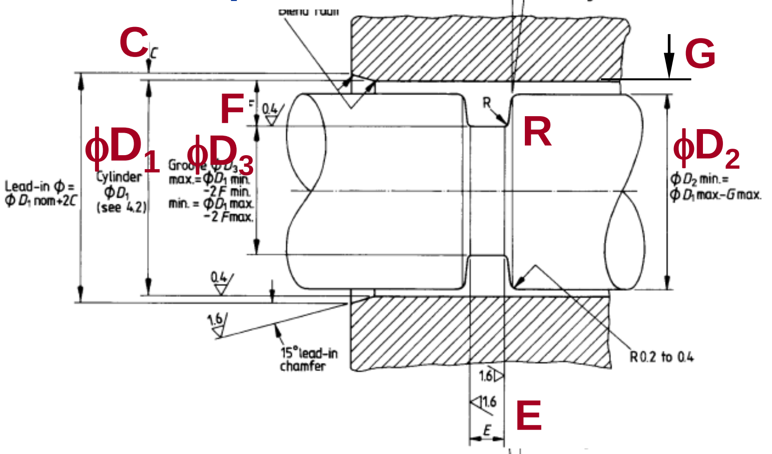
“O”-ring ref. no.	Cross section diameter A	Radial depth F		Groove width $E^{+0.2}_{0}$	Total diametral clearance G (max.)	Lead-in chamfer C	Max. radius R
		max.	min.				
0036-24 to 0176-24	2.4	2.20	2.13	3.2	0.14	0.6	0.5
0195-30 to 0445-30	3.0	2.77	2.70	4.0	0.15	0.7	1.0
0443-57 to 1443-57	5.7	5.38	5.22	7.5	0.18	1.0	1.0
1441-84 to 2491-84	8.4	7.96	7.75	11.0	0.20	1.2	1.0

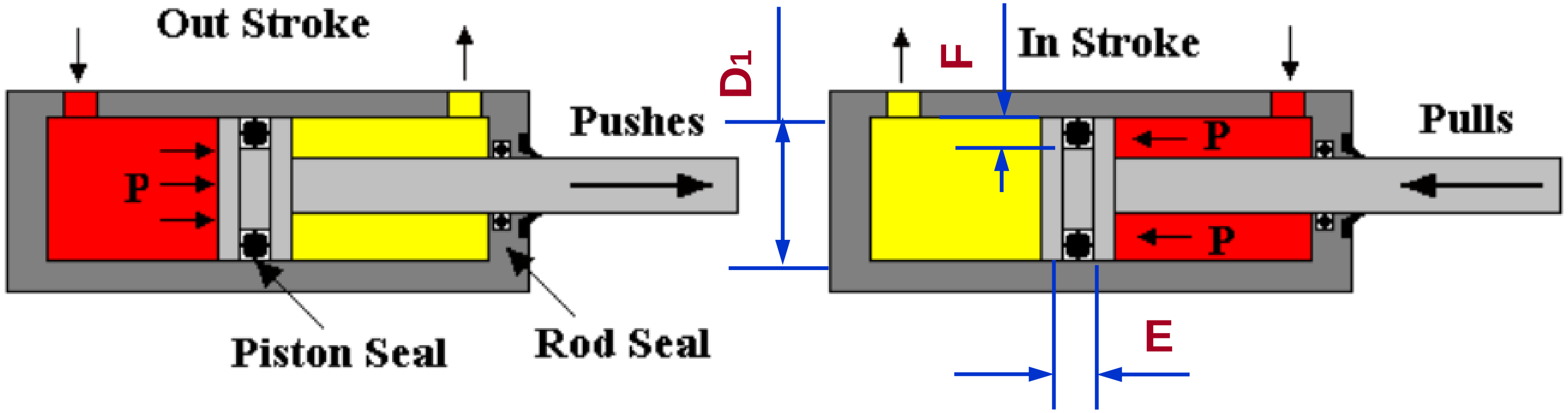
Worked example: “O” ring selection of a pneumatic cylinder

Select “O” rings for cylinder dia **D1=*Φ25* mm** and piston rod dia **d1= *Φ10* mm:**

- For Cylinder: from Table 1, **0221-16**, **0206-24** and **0195-30** are all ok but only **0195-30** is suitable for **pneumatic** applications.
- For Piston rod: from Table 1, **0096-24** is suitable for the piston rod.

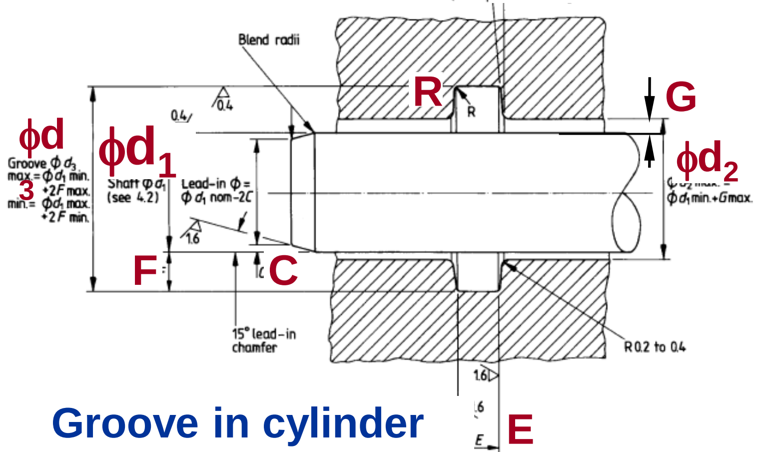
Groove in piston





- **For cylinder from Table 4**
  - **Depth F = 2.70~2.77**
  - **Width E = 4.0 $^{+0.2}$**
  - **Clearance Gmax = 0.15**
  - **Chamfer C = 0.7**
  - **Radius R = 1.0**

- **For piston rod from Table 4**
  - **Depth F = 2.13~2.20**
  - **Width E = 3.2 $^{+0.2}$**
  - **Clearance Gmax = 0.14**
  - **Chamfer C = 0.6**
  - **Radius R = 0.5**



Groove in cylinder

Preparation of CDR report

- **Material selection**
  - A summary of the selected materials for the designed parts
  - Use of material data in calculations including the **weight of the Actuator (using Solidworks)**.

- **Considerations should be given to**
  - Performance, strength, wear resistance, lightweight and cost
  - Suitable routes/processes for manufacturing

- **Some practical points**
  - You may use CES software data in calculations and support decision making **but not to present irrelevant CES bubble charts.**
  - It is a good idea to **use a table** to summarise the selected materials for designed parts, manufacture processes and material data to be used in calculation/evaluation.

Preparation of CDR report

- **Material selection (Generic approach covered in MMME2045)**
  - **Carbon and alloy steels** are commonly used power transmission components, e.g. crankshaft, shafts, gears, pistons, piston rods, fasteners, etc.
  - **AISI/SAE designation** by **Four digits** (**xxyy** with **xx** to define **alloy type** & **yy** to specify carbon contents),

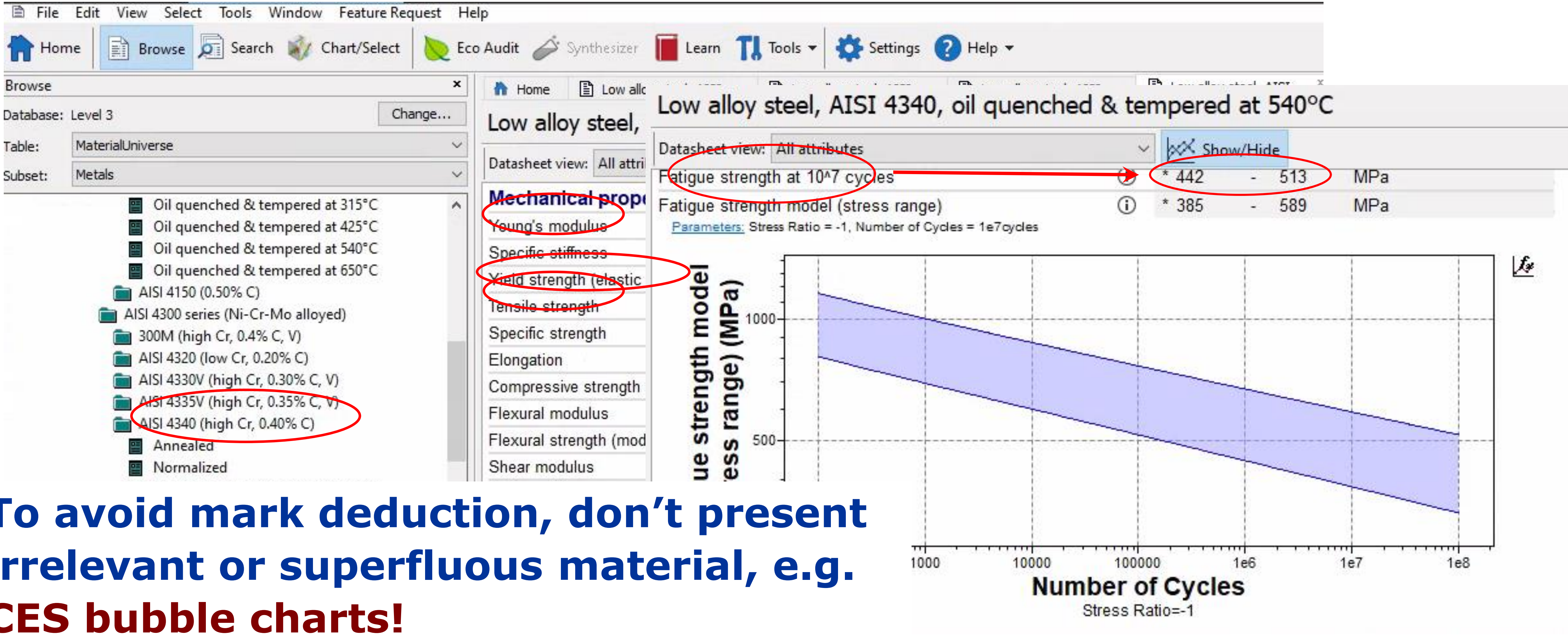
    e.g. **1020** - low carbon steel with **0.2% carbon**, **4140** - chromium molybdenum steel & **4340** - nickel chromium molybdenum steel both with **0.4% carbon.**
  - **High strength Aluminium alloy, e.g. Al7075-T6** (**temper heat treated**) can be used for cylinders in lightweight and corrosion resistance applications.
  - **Cast iron of various types** can be used for cylinders below **10 MPa pressure**, e.g. Gray cast iron (ASTM A48) used for engine and gearbox casing, flywheel, etc.
- **See additional slides on Materials and Heat Treatment** by Prof Geoff Kirk (available in the Individual Design Project section on Moodle)

Preparation of CDR report

- **Heat treatments**
  - **Heat treatment** is a process of heating and cooling at different rates to achieve **desired mechanical properties** through **microstructural changes and phase transformation**
  - **Common heat treatment methods**
    - **Annealing:** heating followed by slow cooling for good machinability
    - **Normalizing:** heating steel to certain temperature and cooling in still or circulated air to obtain a uniform microstructure
    - **Quenching and Tempering:** heating a part to **austenite state** followed by rapid cooling (quenching) and then **reheated (tempered)** to a lower temperature for a good combination of hardness and ductility
    - **Through-hardening:** a heat treatment including annealing, normalizing, and quenching and tempering
  - In the **Gearbox Actuator** project, you need to use **appropriate material properties** via a suitable **heat treatment**

Worked example: select material for piston rod

- **Effective use of CES software (Cambridge Engineering Selector, from MMME2045)**
  - **Piston rod: AISI 4340,** a low alloy steel (Ni-Cr-Mo) for high tensile application



To avoid mark deduction, don't present irrelevant or superfluous material, e.g. CES bubble charts!

Preparation of CDR report

- **Manufacturing processes**
  - **Power transmission components,** e.g. gears, shafts, piston/piston rod and casings are typically manufactured by a route of **shaping** (e.g. casting, forging, machining and grinding), **heat treatments** for enhanced properties and **surface processing** (e.g. polishing and coating) operations.
    - Primary shaping processes: e.g. **forging**, **extrusion, casting, rolling**
    - Machining processes: **manual or CNC machining/turning, milling, drilling**
    - Finishing processes: **grinding, polishing, coating**
  - In the **Gearbox Actuator project**, only main manufacturing steps should be considered to designed parts, e.g. the piston, piston rod/shaft, casing/cylinder

Preparation of CDR report

Assembly drawings (2 A3 drawing sheets)

- **One GA drawing** to show the assembled Gearbox Actuator alone with BOM, Part List table, necessary fits and assembly instructions**. Another GA to show the Actuator** mounted on the Gearbox casing.

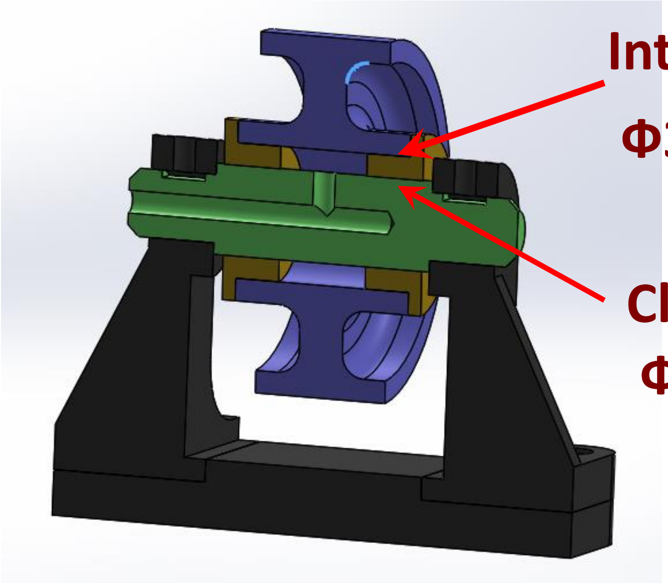
- The GA drawings should show clearly the detailed design of the air motor **using sections, views** and partial views if necessary. The GA drawings should also include all **title block information** to BS 8888 standard.

  - Appropriate choice of views, including placement of cross sections and use of detailed views to show smaller details at larger scale.
  - Appropriate use of ISO standard fits on any critical interfaces between components.
  - Appropriate exclusions of features from cross-sections, i.e. fasteners and features with no internal details such as solid shafts.
  - Appropriate selection of cross-section hatch spacing and angle to show separation of adjacent parts.
  - Appropriate placement of BOM table and BOM balloons.
  - Appropriate notation of critical fits between components.

Preparation of CDR report

Assembly drawings (cont'd)

An example GA of a roller-subassembly (check **CAE3 Task for details on Moodle**)



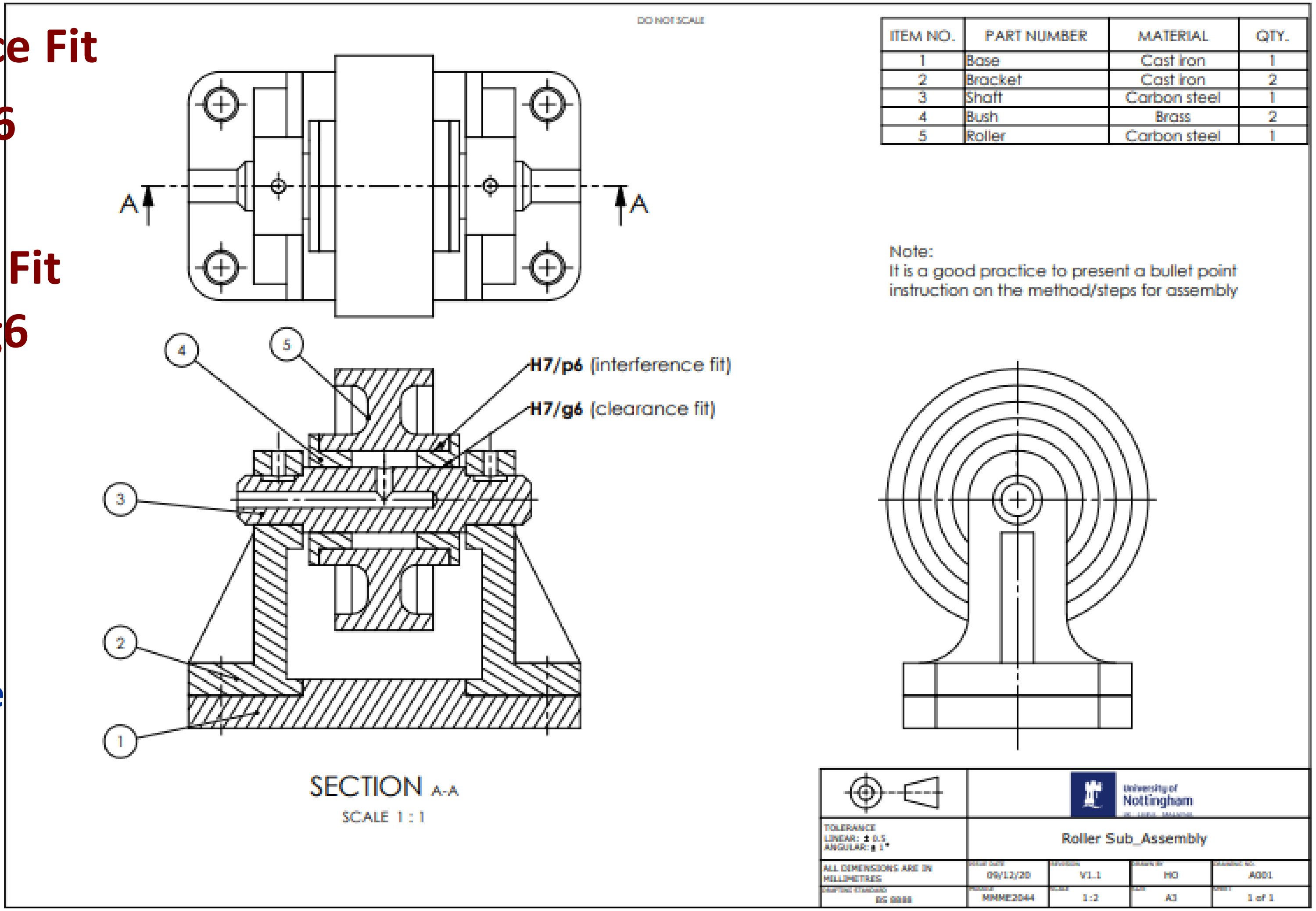
Interference Fit

Φ30 H7/p6

Clearance Fit

Φ20 H7/g6

Roller subassembly from 1st year EDP (see CAE 3 brief slides and SW models on Moodle)



SOLIDWORKS Educational Product. For Instructional Use Only.

- **More GA drawings including GAs of a 2-stroke engine are available on Moodle**
- **In CDR submission, PRINT GA and detail drawings in PDF and combine the drawing sheets with the rest of CDR report**

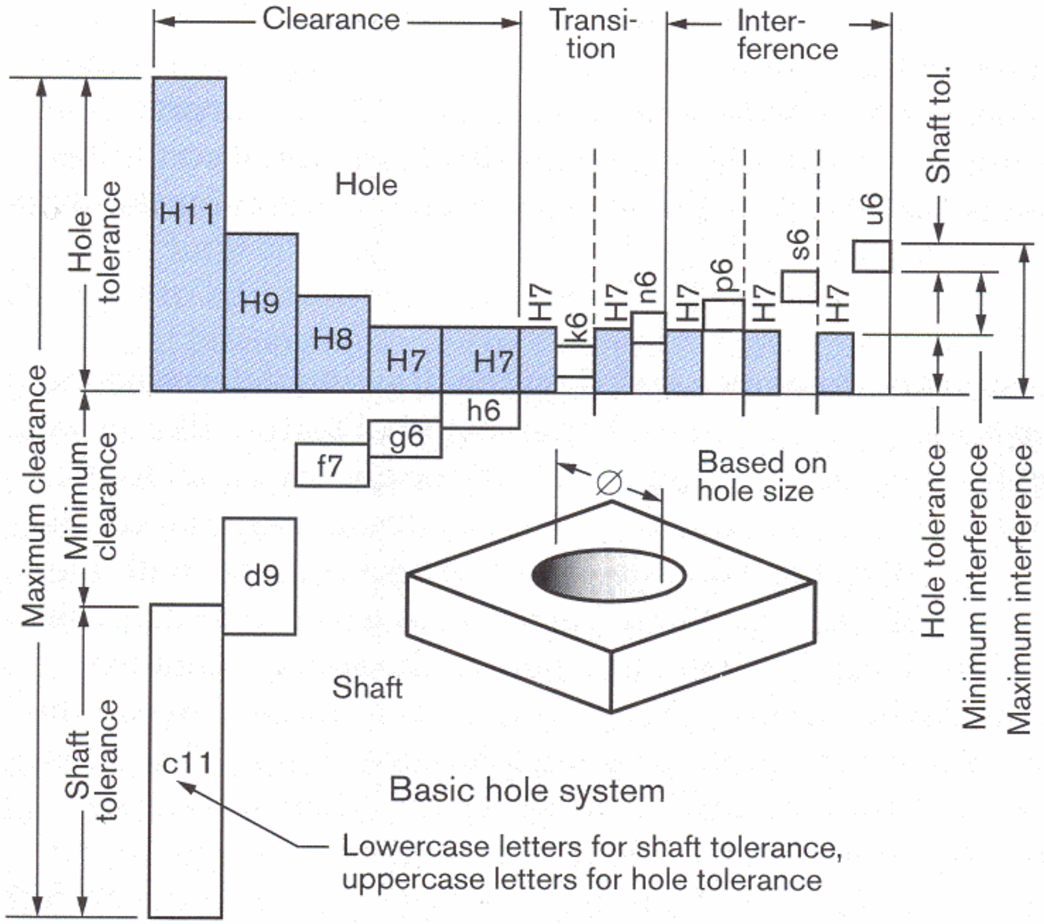
Preparation of CDR report

Assembly drawings (cont'd)

Fits specification using BS 4500A (Hole Basis) (available on Moodle)

Fits are defined to ensure proper function of a machine system:

- **Clearance fits:** shaft smaller than hole to leave a clearance
- **Transition fits:** shaft slightly bigger or smaller than hole for an interference or clearance
- **Interference fits:** shaft bigger than hole to prevent relative motion



Specification of Fits in GA and Tolerances in Detail Drawings

Roller-Sub Assembly as an example (Use BS4500 A)

INTERFERENCE FIT

for Roller & Bushes (Φ30)

H7/p6 is the solution

Roller as Hole:

$\varnothing 30_{0}^{+0.021}$

Bush as Shaft:

$\varnothing 30_{+0.022}^{+0.035}$

CLEARANCE FIT

for Bushes & Shaft (Φ20)

H7/g6 is a choice

Bush as Hole:

$\varnothing 20_{0}^{+0.021}$

Shaft is Shaft:

$\varnothing 20_{-0.020}^{-0.007}$

Extracted from BS 4500 : 1969

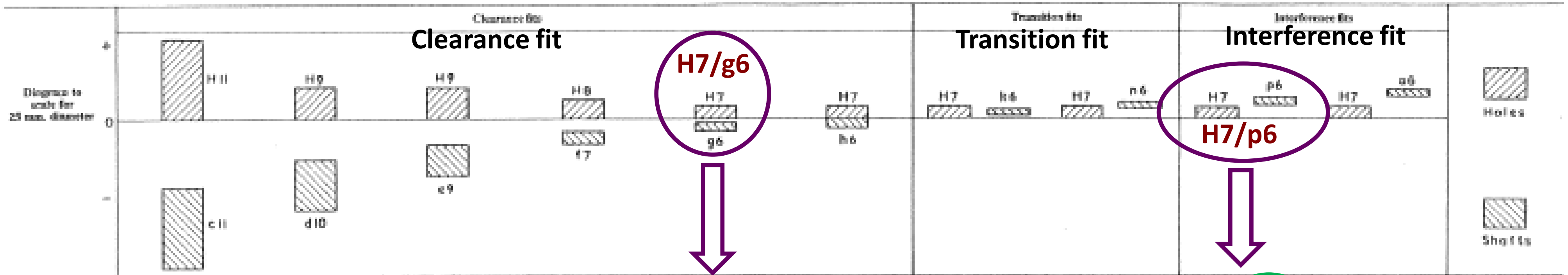
BRITISH STANDARD

SELECTED ISO FITS—HOLE BASIS

Data Sheet 4500A

Issue 1. February 1970

Confirmed August 1985



Nominal sizes Over mm	Nominal sizes To mm	H11 0·001 mm	c11 0·001 mm	H9 0·001 mm	d10 0·001 mm	H9 0·001 mm	e9 0·001 mm	H8 0·001 mm	f7 0·001 mm	H7 0·001 mm	g6 0·001 mm	H7 0·001 mm	h6 0·001 mm	H7 0·001 mm	k6 0·001 mm	H7 0·001 mm	n6 0·001 mm	H7 0·001 mm	p6 0·001 mm	H7 0·001 mm	s6 0·001 mm	Nominal sizes Over mm	Nominal sizes To mm
—	3	+60 0	−60 −120	+25 0	−20 −60	+25 0	−14 −39	+14 0	−6 −16	+10 0	−2 −8	+10 0	−6 0	+10 0	+6 0	+10 0	+10 +4	+10 0	+12 +6	+10 0	+20 +14	—	3
3	6	+75 0	−70 −145	+30 0	−30 −78	+30 0	−20 −50	+18 0	−10 −22	+12 0	−4 −12	+12 0	−8 0	+12 0	+9 +1	+12 0	+16 +8	+12 0	+20 +12	+12 0	+27 +19	3	6
6	10	+90 0	−80 −170	+36 0	−40 −98	+36 0	−25 −61	+22 0	−13 −28	+15 0	−5 −14	+15 0	−9 0	+15 0	+10 +1	+15 0	+19 +10	+15 0	+24 +15	+15 0	+32 +23	6	10
10	18	+110 0	−95 −205	+43 0	−50 −120	+43 0	−32 −75	+27 0	−16 −34	+18 0	−6 −17	+18 0	−11 0	+18 0	+12 +1	+18 0	+23 +12	+18 0	+29 +18	+18 0	+39 +28	10	18
18	30	[illegible] 0	[illegible] −240	[illegible]	[illegible]	[illegible]	[illegible]	+33 0	−20 −41	+21 0	−7 −20	+21 0	−13 0	+21 0	+15 +2	+21 0	+28 +15	+21 0	+35 +22	[illegible]	[illegible]	18	30
30	40	+160 0	−120 −280	+62 0	−80 −180	+62 0	−50 −112	+39 0	−25 −50	+25 0	−9 −25	+25 0	−16 0	+25 0	+18 +2	+25 0	+33 +17	+25 0	+42 +26	+25 0	+59 +43	30	40
40	50	+160 0	−130 −290																			40	50
50	65	+190 0	−140 −330	+74 0	−100 −220	+74 0	−60 −134	+46 0	−30 −60	+30 0	−10 −29	+30 0	−19 0	+30 0	+21 +2	+30 0	+39 +20	+30 0	+51 +32	+30 0	+72 +53	50	65
65	80	+190 0	−150 −340																	+30 0	+78 +59	65	80
80	100	+220 0	−170 −390	+87 0	−120 −260	+87 0	−72 −159	+54 0	−36 −71	+35 0	−12 −34	+35 0	−22 0	+35 0	+25 +3	+35 0	+45 +23	+35 0	+59 +37	+35 0	+93 +71	80	100
100	120	+220 0	−180 −400																	+35 0	+101 +79	100	120
120	140	+250 0	−200 −450	+100 0	−145 −305	+100 0	−85 −185	+63 0	−43 −83	+40 0	−14 −39	+40 0	−25 0	+40 0	+28 +3	+40 0	+52 +27	+40 0	+68 +43	+40 0	+117 +92	120	140
140	160	+250 0	−210 −460																	+40 0	+125 +100	140	160
160	180	+250 0	−230 −480																	+40 0	+133 +108	160	180
180	200	+290 0	−240 −530	+115	−170	+115	−100	+72	−50	+46	−15	+46	−29	+46	+33	+46	+60	+46	+79	+46 0	+151 +122	180	200
[illegible]	[illegible]	+290	−260																	+46	+159	[illegible]	[illegible]

Note: BS 4500A & BS 4500B charts are available on Moodle

Preparation of CDR report

ONLY TWO detail drawings (Actuator casing and shaft/piston rod)

NO cutting list, process sheets or manufacturing plan as this is a design task

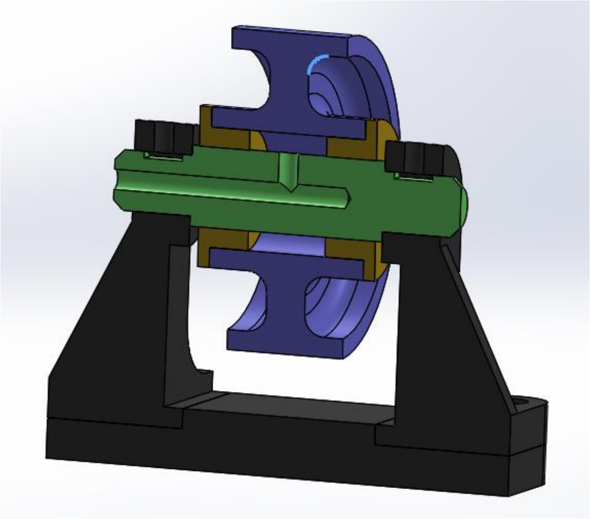
- **A detail drawing** should include **all the necessary information required for the definition of the part**, e.g. material, properties, dimensions and tolerances.
- **Dimensions and tolerances** are clearly defined for **intended function, easy manufacturing and inspection with datum feature established**.

- A complete set of required dimensions, drawn from appropriate datums.
- Tolerances on all dimensions that have a specified fit in the GA drawing.
- Appropriate part naming conventions matching the GA bill of materials.

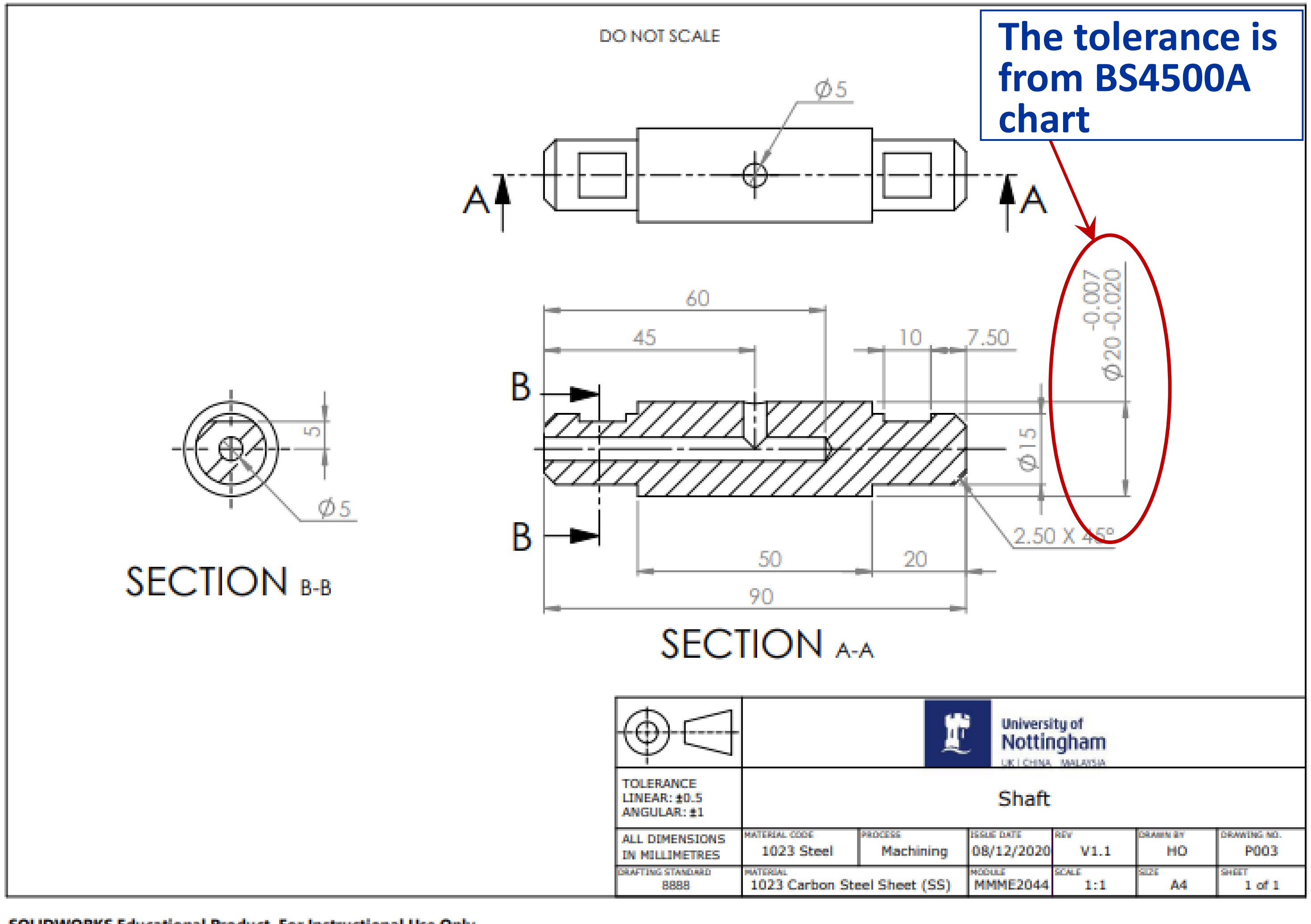
Preparation of CDR report

Detail drawings and process sheets (cont'd)

Roller-subassembly: Detail drawing of the Shaft

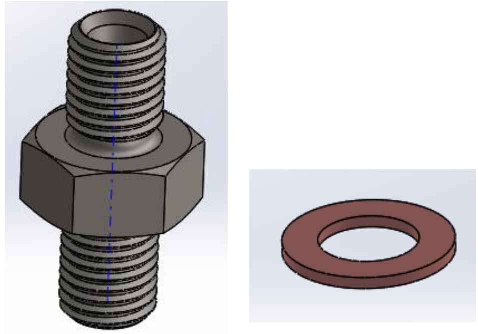


Roller subassembly from 1st year EDP (see CAE 3 brief slides and SW models on Moodle

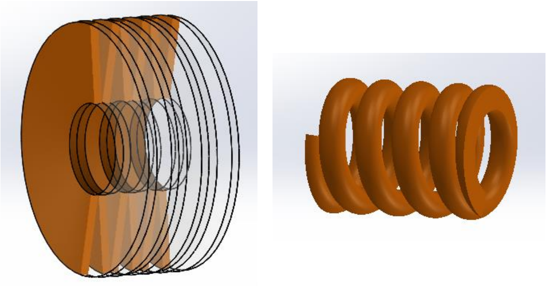


A few more items for CDR submission

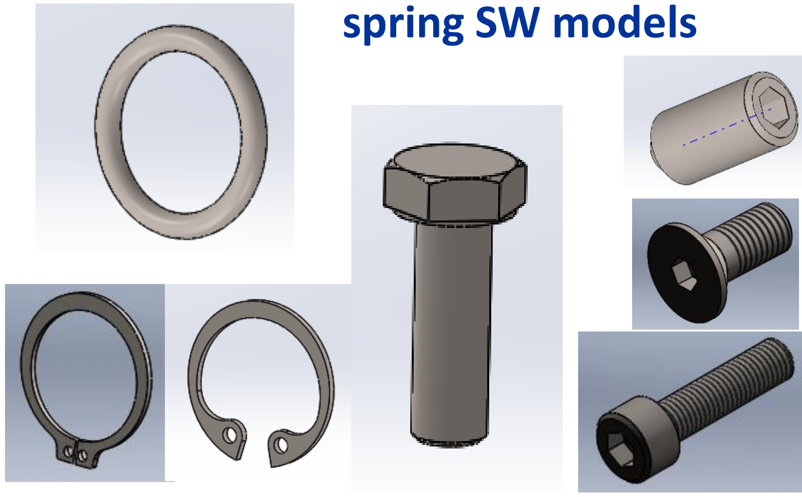
- Use SW models of **M8 oil union & seal washer** available on Moodle
- Use https://www.leespring.co.uk/ to download SW models of disc or compression springs or create SW models yourself
- Use **SW Toolbox to access standard parts**, e.g. BS4518 “O” rings, Bolts, nuts and washers, circlips & set screws
- Make sure the Actuator is properly mounted on Gearbox casing and connected to Gearbox clutch fork
- Compile SW models and files using the **template folders**



M8 oil union & seal washer



Leespring Disc & coil spring SW models



SW Toolbox standard parts of “O” rings, circlips and fasteners

What to do next?

- Start working on Solidworks modelling, GA and detail drawings
- Update engineering calculations and material selection sections
- Work effectively with **your tutor** in **Design sessions in the coming weeks**
- Work on your **CDR report using the pro-forma** in a clear and concise manner
- Organise all the files, CDR report, SW models and spreadsheet files
- Attend the CAE and Project Support sessions (**4-6pm, Fridays in Coates C19**). If needed we can arrange additional support sessions
- Get ready to submit your CDR on **Moodle** by **3:00pm**, **Friday, 31st March**

➢ Please pay an attention:

- **Back up all your files, Solidworks models, drawings, CDR report, etc, regularly, to avoid sudden loss of data** (not a reason for EC approval)
- **Be aware of University's policy on Academic integrity & misconduct,** check link.
- **Let me** and/or **Khaled Goher** know if you have specific cases for discussion.

Feedback

- **Feedback** will include **completed mark sheet** (available on Moodle) and **feedback on design** in the **1st Design Session in the Spring semester**
  - **Satisfactory** - The deliverable was achieved on time to a **satisfactory standard** – you can proceed with your final design solution.
  - **Category 1 Deficiency** - The deliverable was not achieved or there was a **major deficiency**. The deficiency needs to be addressed before manufacturing sessions.
  - **Category 2 Deficiency** - The deliverable was achieved but there was a **minor deficiency** to be addressed before manufacturing sessions.
  - **Observation** - Items that are acceptable but **can be improved**.
- **Additional feedback sheet on CDR submission will be made available**