Macalloy

POST TENSIONING SYSTEM

CONCRETE ENGINEERING

Macalloy 1030
Macalloy S1030
Post Tensioning System

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The System

The Macalloy 1030 Post-tensioning bar consists of high tensile alloy steel bars in diameters from 25mm to 75mm provided with cold rolled threads for part or full length, together with a range of fittings. Bars from 25mm to 50mm diameter obtain their specified properties by cold working. Bars of 75mm diameter obtain their specified properties via a quenched and tempered process. Stainless steel Macalloy S1030 bars in diameters from 20mm to 40mm are made from precipitation hardened stainless steel.

Sizes

Macalloy bars of standard quality are available in lengths up to 17.8m for diameters between 25mm and 50mm and up to 8.4m for 75mm diameter. Stainless Macalloy bars are available in lengths up to 6m for all diameters from 20mm to 40mm. Greater tendon lengths can be obtained by joining Macalloy bars with threaded Macalloy couplers.

Non-standard bar diameters can also be provided by arrangement. Physical parameters of Macalloy 1030 bar are given in Table 1.

Steel Quality

Macalloy 1030 is a carbon-chrome steel with a composition designed to give the specified properties. All bars are hot rolled. Diameters from 25mm to 50mm are cold worked by stretching. The stretching load and permanent elongation are predetermined by preliminary tests and the properties are monitored during production to ensure that the bars as supplied comply in all respects with the provisions of BS4486.

Bars of 75mm diameter are heat treated after rolling at a controlled temperature and time to ensure that the steel has the same physical properties as for other diameters. Rigorous inspection and testing are carried out, both during and after treatment, to ensure consistent tensile properties.

Macalloy S1030 is a martensitic nickel-chrome alloy steel, hardened during manufacture to attain the specified properties.

The nominal mechanical properties of both Macalloy 1030 and Macalloy S1030 bars are listed in Table 2.

Table 1 Range of Macalloy 1030 Bar

Nominal diameter	Nominal cross sectional area	Mass		Major diameter of threads	Minimum hole diameter in Steelwork
		Macalloy 1030	Macalloy S1030 Stainless		
mm	mm^2	kg/m	kg/m	mm	mm
20	315	–	2.53	22.0	24
25	491	4.09	4.09	28.9	31
26.5	552	4.58	–	30.4	33
32	804	6.63	6.63	36.2	40
36	1018	8.35	–	40.2	44
40	1257	10.30	10.30	45.3	49
50	1963	15.72	–	54.8	59
75	4185	33.0	–	77.2	82

Table 2 Mechanical Properties

Grade	Characteristic ultimate tensile strength	Minimum 0.1% proof stress	Minimum elongation	Approximate modulus of elasticity
	N/mm^2	N/mm^2	%	kN/mm^2
Macalloy 1030 25-50mm	1030	835	6	170
Macalloy 1030 75mm	1030	835	6	205
Macalloy S1030	1030	835	10	185

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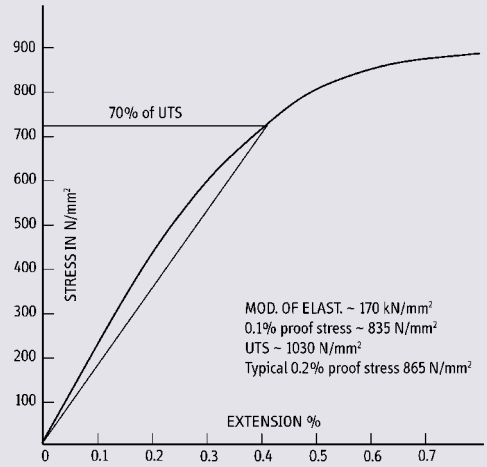
Strength

The specified characteristic failing loads and the minimum 0.1% proof loads for the two grades of Macalloy 1030 Bar steels are given in Table 3.

Bars can be supplied with nuts, washers, plates, couplers, turnbuckles, grout flanges, forks and pins as required. All fittings are designed to transmit the failing load of the threaded bars in conformance with the gripping and anchorage efficiency provisions of BS4447 for both static and dynamic loading.

Typical stress strain diagram for cold worked Macalloy 1030 bar (25-50mm)



Quality Control

Macalloy operates a quality assurance system complying with the provisions of BS EN ISO 9002, and have product approval to BS4486 and BS4447 from CARES (UK Certification Authority for Reinforcing Steels).

The details within this brochure are in accordance with the current British Standards, however the system has approval to the National Standards in Germany and France.

Among other requirements, the following controls apply to all cold worked Macalloy 1030 production:

Bars: A test sample is taken from each 5 tonne batch of bars during processing. The sample is tested, on site using a NAMAS calibrated 2500kN capacity tensile testing machine, to verify that the specified tensile properties are achieved. The identity and test status of all material is closely monitored from delivery to our works, during the production process, to receipt by the customer.

Fittings: A sample of all fittings is taken at random from each batch manufactured, and checked for dimensional tolerances, thread tolerances, hardness and the presence of cracks. Couplers are 100% checked to detect cracks. All fittings are marked to ensure full traceability.

Assemblies: Anchorage and coupled joint assemblies of all sizes of bar are tested to destruction at a rate governed by production, to ensure compliance with the provisions of BS4447.

Proof Loading: Facilities are available to test load tendon assemblies up to 2500kN.

Table 3 Characteristic Loads

Nominal diameter	Characteristic failing load		Minimum 0.1% proof load	
	Macalloy 1030	Macalloy S1030	Macalloy 1030	Macalloy S1030
mm	kN	kN	kN	kN
20	–	323	–	262
25	506	506	410	410
26.5	569	–	460	–
32	828	828	670	670
36	1049	–	850	–
40	1295	1295	1050	1050
50	2022	–	1639	–
75	4311	–	3495	–

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Working Load Factors

The working load factor to be used in a design is at the discretion of the Engineer but will normally be that specified in the appropriate British Standard.

For prestressed concrete construction, the current standard for buildings is BS8110 and for bridges BS5400, which suggest an initial prestressing force of 70% of the characteristic failing load. For ties and similar applications in structural steel construction, the requirements of BS5950:Parts 1 and 2 apply.

Ground anchorage design is dealt with in BS8081 which gives recommended load factors for permanent and temporary applications.

Properties

Extensive data and test reports on bars and components are available from Macalloy's Technical Department.

The main properties are summarised as follows:

Fatigue – threaded assemblies have a fatigue resistance in excess of two million cycles of loading over a tensile stress range of 590-670 N/mm^2, exceeding the requirements laid down in BS4447.

Relaxation – the requirement laid down in BS4486 for the loss of stress due to relaxation in a bar loaded to 70% of its actual breaking load after 1000 hours at room temperature, is 3.5% maximum. This is comfortably achieved with typical results below 3.0%.

Anchorage strength – anchorage efficiency tests in accordance with the requirements of BS4447 are carried out to verify that the failing load in the anchorage is not less than 92% of the actual failing load in the adjacent parent bar, and that the failing load in a coupled joint is not less than the characteristic failing load of the bar diameter under test.

Stress corrosion – Macalloy 1030 bars have been subjected to the F.I.P. standard stress corrosion test. No bars failed during the 200 hour duration of the test and subsequent tensile tests to failure showed no significant reduction in the ultimate or 0.1% proof stresses. Under normally occurring conditions, Macalloy 1030 is not susceptible to stress corrosion. Macalloy 1030 is, of course, subject to surface corrosion when exposed to moisture and deep corrosion pitting is harmful. Further data is available from the Technical Department.

Macalloy S1030 has very good general corrosion properties similar to grades 303 and 304 austenitic stainless steel bars. In industrial atmospheres some surface discolouration may occur over a period of time.

It has excellent stress corrosion and fatigue properties, well in excess of the code requirements and, where surface appearance is not critical, Macalloy S1030 provides an excellent high strength, long life tendon.

Bending – post tension bars may be stressed to full load in a curved profile, provided the radius of curvature is not less than 200 diameters.

Welding

Macalloy 1030 and Macalloy S1030 must not be welded, subjected to high local heating or splashed with weld metal.

Threads

A coarse thread is rolled directly on to the bar surface, of a form specially designed to give speed and ease in assembly. The thread has excellent fatigue properties and attains the desired anchorage strengths.

The bond value of the coarse thread when cast into concrete, or grouted into a preformed hole, complies with the requirements for a class 2 deformed bar.

The threads are rolled on the bars in the factory with stringent controls on tolerance and form. Load is transferred from bar to fittings for the full circumference of the bars. Hence the fittings are compact and load transfer efficiency easily complies with the requirements of BS4447.

Short, fully threaded bars can be used satisfactorily for short tendons and bolts as loss of load due to 'take up' in the threads on transfer of load is minimised by the controlled limits on clearance between internal and external threads.

All available lengths of bar can be fully threaded.

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Protection Against Corrosion

For normal prestressed concrete construction the alkaline environment provided by a layer of cement grout injected into the duct enclosing the bar gives good protection.

If bars are used in any exposed application, corrosion protection is essential for Macalloy 1030 and can be advantageous for Macalloy S1030.

The type of protection will be governed by the conditions of exposure, appearance and cost. Among available options are: paint systems comprising primer and one or more finishing coats, grease impregnated tape wrapping, adhesive coated plastic tape wrapping, shrink wrap plastic tubing, rigid plastic tubing with injected grease or grout.

Two or more of these systems may be combined to enhance the degree of protection.

Particular care is always needed at end connections and coupled joints to ensure continuity of protection over the whole tendon.

Advice is available from Macalloy's Technical Department.

Torque Loadings

Calibrated torque wrenches may be used to apply loads up to 25% of the characteristic failing load. The accuracy of the load induced in the bar is in this case much less than when applied by hydraulic jack as it is not possible to determine the friction loss in the threads with any precision.

The formula for calculating the approximate torque to apply and axial load is:

$$\text{Torque} = \frac{P \times D}{K} \text{ Nm}$$

where P is the desired axial load in kN

D is the nominal bar diameter in mm

K is a constant obtained by test measurements

Table 4 K Values for Macalloy Coarse Threads

Bar Diameter	K
mm	
25	4.1
26.5	4.3
32	4.7
36	4.9
40	4.5
50	4.1

Stressing Procedure

Hydraulic jacking equipment is available to apply load to the bars. Jacks are provided with gauges calibrated against a certified load cell to register the force exerted on the bars. In addition, load cells are available to give an independent check on the accuracy of the pump gauge if necessary.

Anchorage recess dimensions must give clearance for the stressing bridge or stool to seat on the end plate, and for access to the ring or box spanner to tighten the nut. Clearance is also required on one axis for the hose connections to the body of the jack.

Hand and air operated pumps are available to drive the full range of jacks.

Stressing procedures and jack details are available from Macalloy's Technical Department.

Figure 1 Jack details

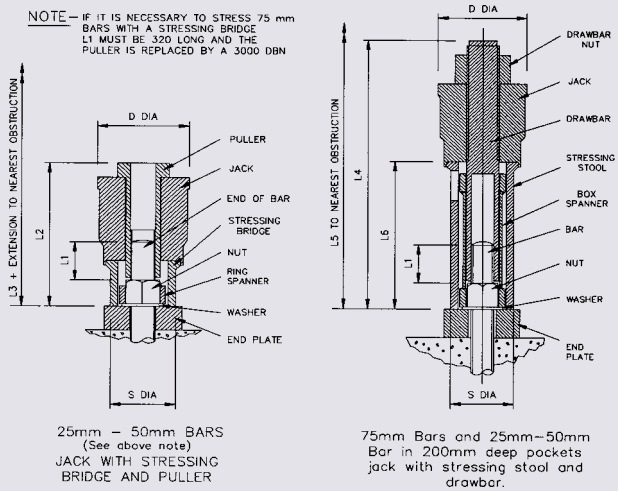

Table 5 Jacking Dimensions

Jack type	Weight	Max load	Bar dia.	Min bar centres	D. Dia	S. Dia	L1 (min)	L2	L3	L4	L5	L6	Min pocket dia.
3000	50 kgs	3000kN	75 50	170 160	250	187	135 90	330	– 450	855	1300	500	200
1000	26kgs	1000kN	40 36 32	120 116 114	176	125	75 65 60	301	385 370 360	564	850	300	135
450	15kgs	450kN	26.5 25	90 88	129	100	50 45	281	340 330	566	870	300	110

All jacks have 50 mm stroke. All dimensions in mm.

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Table 6 Physical Parameters

	Item	Unit	†	Nominal Bar Diameter – mm						
			20	25	26.5	32	36	40	50	75
Bars	Sectional area	mm^2	314.2	490.9	551.5	804.3	1017.9	1256.6	1963.5	4185.4
	Mass per metre	kg	2.466	4.069	4.560	6.661	8.451	10.41	16.02	33.2
	Metre run of bar per tonne	m	405	246	219	150	118	96	62	30
	Characteristic failing load	kN	314	506	569	828	1049	1295	2022	4311
	Prestress at 70% characteristic	kN	220	354	398	580	734	907	1415	3018
	Minimum centres for anchorage	mm	100	100	110	125	140	150	175	250
Flat nuts*	Nut reference		SN20	FN25	FN26.5	FN32	FN36	FN40	FN50	FN75
	Length	mm	25	33	37	41	46	51	71	100
	Width across flats (DIA for 75mm bar)	mm	42	46	50	56	62	65	90	135
Flat washers*	Washer reference		SSW20	FSW25	FSW26.5	FSW32	FSW36	FSW40	FSW50	
	Outside diameter	mm	50	60	65	70	75	80	105	
	Thickness	mm	5	5	5	5	5	5	5	
Couplers	Coupler reference		SC20	FC25	FC26.5	FC32	FC36	FC40	FC50	FC75
	Outside diameter	mm	35	42.5	42.5	50	57.5	62.5	76	110
	Length – standard	mm	–	85	90	115	130	140	170	230
	Length – stainless	mm	65	80	–	95	–	120	–	–
End plates	Plate reference		SSF20	FP25	FP26.5	FP32	FP36	FP40	FP50	FP75
	Length	mm	100	100	110	125	140	150	200	300
	Width	mm	100	100	110	125	140	150	175	250
	Thickness – standard	mm	25	40	40	50	50	60	60	75
	Hole diameter	mm	26	35	36	41	45	52	61	82
	Thickness – threaded	mm	–	40	40	50	50	60	70	100
Ducts	Sheathing i/d	mm	41	41	41	50	50	61	71	91
	Coupler-sheathing i/d recommended	mm	50	59	59	66	71	75	91	125
	Coupler-sheathing minimum	mm	45	52.5	52.5	60	65	70	90	125
Grouting flange	Flange reference		–	GF25	GF25	GF32	GF36	–	–	–
	Length /o/dia	mm	–	125	125	140	140	–	–	–
	Height	mm	–	40	40	40	40	–	–	–
Threads	Pitch	mm	2.5	6.0	6.0	6.0	6.0	8.0	8.0	8.0
Standard thread lengths (see fig 2)	Length – jacking end (standard) S1	mm	250	250	250	250	250	250	250	350
	– dead end (standard) S2	mm	100	100	100	100	100	100	100	150
	– coupler (standard)	mm	40	45	50	60	65	75	85	150
	X1 (MIN)	mm	75	82	91	105	115	130	165	235
	X2 (MIN)	mm	42	49	53	57	62	71	91	116
	X3 (MIN)	mm	12	12	12	12	12	16	16	16

***Spherical nuts and washers are available to accommodate rotation if required. †Available in stainless grade only.**

Figure 2 End thread dimensions

X1 = live end
X2 = dead end
X3 = length of bar past nut or thro' threaded plate
= 12 for 6mm pitch
16 for 8mm pitch

S1 = live end thread
S2 = dead end thread

L = length over plates

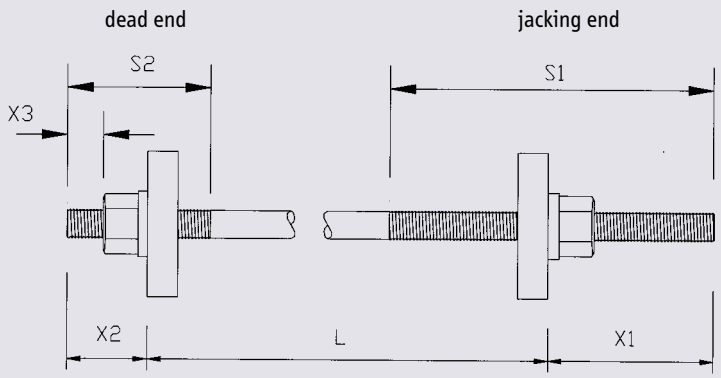

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Figure 3 Typical end block arrangement (shown for 32mm bar)

Note: Duct omitted for clarity.

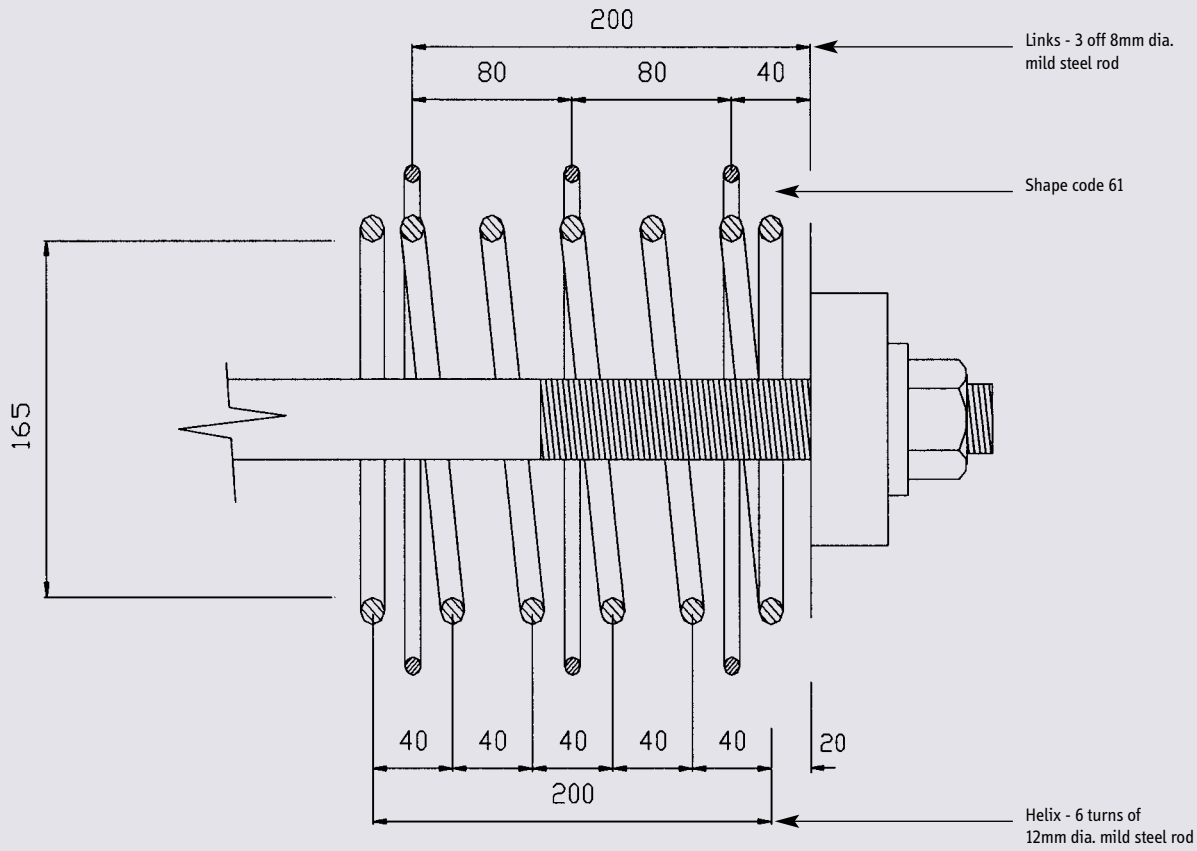

Table 7 Suggested Mild Steel End Block Reinforcement (helix **and** links must be used together with minimum 35N/mm² concrete – see Figure 3)

Macalloy	Helix				Links		
dia. mm	Rod dia. mm	I/D mm	Pitch mm	Turns mm	Rod dia. mm	CRS mm	Number
25	12	130	40	5	8	70	3
26.5	12	130	40	5	8	70	3
32	12	165	40	6	8	80	3
36	12	195	40	7	8	80	4
40	12	220	40	7	8	80	4
50	16	250	50	8	10	100	4
75	20	350	75	8	16	100	6

Note: A longitudinal length of rod may be used to attach the links but it is not required as part of the reinforcement.

Detailing

There are many permutations possible to achieve satisfactory construction details, and advice is readily available from the technical department.

Figure 4 shows typical tendon assemblies.

More detailed explanation of the Macalloy Post Tensioning System is available in the Macalloy Design Data Handbook.

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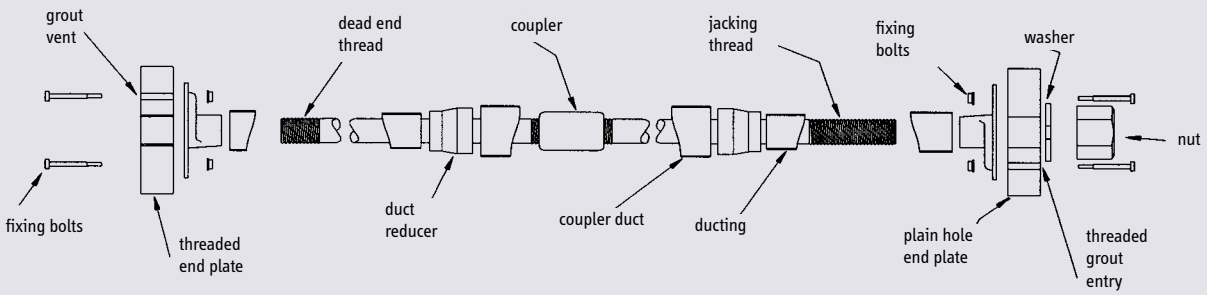
Applications

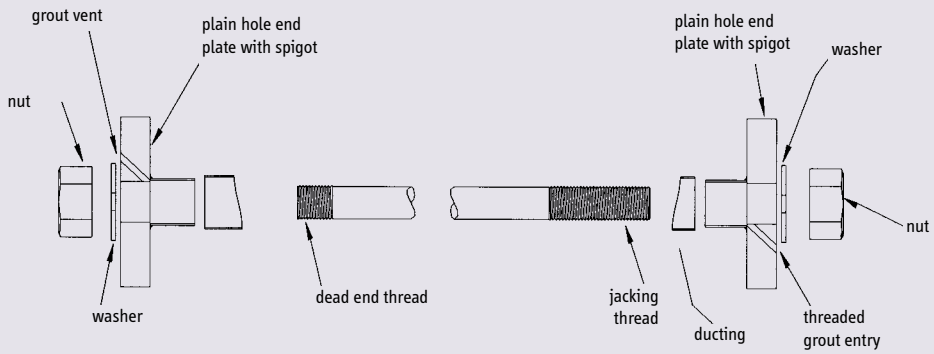
Macalloy bars were developed initially for use in prestressed concrete construction but have been adopted for many structural applications. Among these are:

- Stressed connections
  - – concrete to concrete
  - – concrete to steel
  - – steel to steel
- Prestressed block and brick construction
- Anchor bolts for tension ties
- Holding down bolts
- Friction grip bolts and clamps
- Hangers
- Structural steel frame ties
- Ground and rock anchorages
- High strength portal, ground or sheet pile ties
- Temporary or partial prestressing
- Pile testing

Figure 4 Typical tendon assembly for Macalloy bars



25mm to 36mm dia.



40mm to 75mm dia.

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This publication gives the design parameters currently used by Macalloy in the manufacture and installation of prestressing bar systems.

The company reserves the right to amend technical details as and where necessary, in line with its policy of continuous product development.

Should the designer require any further information on this system or any other Macalloy products, please contact our Technical Department.

Z-13.1-74 MPA BAU TU MÜNCHEN Z-12.4-59 MPA BAU TU MÜNCHEN CARES QUALITY SYSTEMS ISO 9000 UKAS QUALITY MANAGEMENT 002 CARES UKAS PRODUCT CERTIFICATION 002

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