

## **Orthopedic Introduction**

Orthopedic surgery or orthopedics (BE: orthopaedics) is the branch of surgery concerned with acute, chronic, traumatic and recurrent injuries and other disorders of the locomotors system, its muscular and bone parts. Apart from the mechanical considerations, it is also concerned with the pathology, genetics, intrinsic, extrinsic and biomechanical factors involved.

## **The treatment of fractures**

### **Primary aims of fracture treatment are:**

- a) The attainment of sound bony union without deformity
- b) The restoration of function, so that the patient is able to resume his former occupation  
and pursue any athletic or social activity he wishes.

To these might be added 'as quickly as possible' and 'without risk of any complications, whether early or late'. These aims cannot always be achieved, and in some situations are mutually exclusive. For example, internal fixation of some fractures may give rapid restoration of function, but at the expense of occasional infection. The great variations that exist in fracture treatment are largely due to differences in interpretation of these factors and their relevance in the case under consideration

### **Priorities of treatment/ multiple injuries**

If a fracture is a patient's sole injury, it is usually possible to proceed with its treatment without undue delay (although unfitness for anaesthesia may sometimes upset this ideal). If, however, a fracture is complicated by damage to other structures, or involvement of other systems, then treatment of the fracture usually takes second place. Immediate action must be taken to correct any life-endangering situation which may be present or anticipated. Therefore, when the patient is first seen, a rapid overall examination must be made to detect any condition which merits priority in treatment. In case of multiple injury, especially when the patient is unconscious, routine

screening films of the skull, cervical spine, chest and pelvis should be carried out, along with an ultrasound examination of the abdomen.

### **Treatment of the fracture itself**

a) Undue movement at the fracture site should be prevented by the use of temporary

splintage until radiographic and any other examination are complete.

This will reduce

pain and hemorrhage, and minimize the chances of a closed fracture becoming open.

b) If the deformity is so great that the viability of the skin overlying a fracture or

dislocation is seriously endangered, it is usually advisable to do something to correct

this. In many cases gentle repositioning of the distal part of the limb is sufficient; the

use of entonox may be required.

c) If the fracture is an open one, a bacteriological swab should be taken and the wound

Covered with sterile dressings. Appropriate antibiotic therapy should be commenced

Immediately.

d) The fracture should be fully assessed by clinical and radiological examination: the site,

Pattern, displacement and angulation should be noted. Involvement of the skin, and

Damage to related structures such as important nerves or blood vessels, should be

Determined.

## **Product profile**

### **What are Orthopaedic implants?**

Whenever there is a fracture to the bone, to facilitate the union of the bone, implants are used. Implants are used to assist the healing of the bone. However they are not substitute to the bone and cannot bear the weight of the body effectively like the bone. Implants are made up of stainless steel of 316 grade certified for use in human body.

### **What are DCP plates**

Plates are the devices, which are fixed on the bone to facilitate union of bone. DCP is Dynamic Compression plate. The holes of the plates are oval shaped to provide compression. These plates are available in three sizes: Broad, Narrow & Small.

Broad and Narrow DCP plates are used for larger bones, such as tibia and femur. Small DCP is used for smaller bones like Radius, Ulna and Humerus. 4.5 mm cortical screws are used in broad and narrow DCP plate and 3.5mm cortical screws are used in small DCP plate. Available from 4 holes to 12 holes.

### **What are LC DCP plates ?**

These plates alike DCP plates, but the posterior side of the LC DCP is undercut along the holes. It provides 40% inclination of the screws which is helpful in oblique fractures. Normal DCP plate allows 25% inclination of the screws. Because of the undercuts the surface contact with the plate is limited and the blood supply is not affected.

### **What are types of DHS plates ?**

DHS plate are available in various angles from 120 to 145 with 5 difference. The length of the plate depends upon the number of holes invariably from 2 holes to 16 holes.

### **What is the use of DHS plates (Dynamic Hip Screw)**

DHS plates are used for Hip fractures (in the subtrochanteric region of the femur bone).

This plate is available in the angles of 120, 125, 130, 135, 140 and 145 and in sizes

depending on the number of screw

### **What is DCS plate (Dynamic Condylar Screw)**

This plate is used for the condylar fractures in the femur. The angle of the plate is 95

And the same DHS top screw is used. It available from 4 holes to 12 holes

### **NAILING:-**

#### **What is interlocking?**

Interlocking is known as Intra medullary nailing system where in the nail is implanted in the medullar cavity of the bone. The nail has slots in it through which the bolt is passed and locking is achieved. It helps in bringing the fractured segment closer. The advantage of interlocking is it minimizes the blood loss.

#### **What are Interlocking Nails?**

These are the gun drilled nails, which are implanted in the intra medullar cavity of the bone. The nail has slots in it through which the bolt is passed and locking is interlocking is it minimizes the blood loss.

#### **What are types of interlocking nails?**

There are various types of interlocking nails:

Tibia, Femur, Subtrochanteric, Recon, Supracondylar and Humerus.

#### **Tibia Nail:-**

Used for fracture in the tibial bone below the knee

Size: Dia: 7, 8, 9, 10mm Length: 26mm-40mm (1cm diffn)

### **Compression Tibia:-**

Used for fracture in the upper bend of tibial bone below the knee  
Size: Dia: 9, 10, 11, 12mm Length: 34mm-48mm (1cm diffn)

### **Recon Nail:-**

When there is a cross fracture in the femoral neck bone recon nail is used.  
Size: Dia : 9, 10, 11mm. Length : 36mm-42mm (Left and right) (2cm Diffn)

### **Supracondylar Nail:-**

Used for the femoral bone in case of multiple fractures.  
Size: Dia: 10, 11, 12mm Length: 18mm-28mm (2cm diffn)

### **Humerus Nail:-**

Used for the humerus bone in the arm.  
Size: Dia: 6.5, 7, 8mm Length: 18mm-28mm (2cm diffn)

### **Proximal femur Nail:-**

Used for Subtrochanteric fracture : 9, 10, 11, 12.

### **What are Square Nails?**

Square Nails are used for fractures related to radius and ulna.  
Radius ulna are the bones of the forearm, square nails are inserted in the medullar cavity of radius and ulna.

### **What are K. Nails?**

K nails are the simplest type of intra medulla nails, they are implanted in the medullar cavity of the bone. The only basic difference between interlocking nails and K- nails is that the bolts cannot lock the K-nail, In short it is the cheapest option available to the non-affording patient.

## **INSTRUMENTS**

### **What are Orthopaedic instruments?**

There are various orthopaedic instruments used to insert implants for healing fractures. There are various kinds of instruments such as Zig,Bolts,Curved Bone,Awl,Triple Reamer,Tap,etc.these are all used in surgeries.

### **What are Orthopaedic instrument sets?**

Interlocking sets:Tibia,Femur, Supracondylar,Recon, Humerus.Small fragment instrument set, Basic Instrument set, Plating set,DHS Instrument set,Condylar Plate Instrument set,Cannulated Cancellous Screw set, Illazarov Set.

### **What are the types of External Fixators?**

The type of external fixators are :Clamps,Rods, Schanz screws, Steinmen Pins and Illazarov method.

### **What is Sterilization?**

Sterilization is a process in which the implant is sterilized so that after the implant is induced in the body it will be free from any infections.

### **What is gamma radiation?**

Gamma radiation is the process of Sterilization in which the implant are exposed to gamma rays and it eradicates the bacteria to keep free from infection in different types of viruses.

### **How are the implants sterilized?**

Sterilization is done by 2 ways.

- 1.Gamma radiation
- 2.E.T.O

## **What is E.T.O sterilization?**

In this procedure implants are sterilized by using Ethylene Trioxide.

## **What is flexible reamer?**

Reamers are used for reaming the medullar cavity before insertion of the nail. Reaming increases the medullar cavity so as to help the insertion of nail. Inflexible reamer, the reamer shaft is flexible and is passed over the guide wire with replaceable tips of different diameters at its end

## **INSTRUCTIONS FOR USE:**

### **For use by an Accredited Orthopaedic Surgeon only.**

#### **1. Purpose:**

Bone Plates, bone Screws, Intramedullary Nails, Pins and Wires are intended to aid in surgical stabilization following operative procedures to treat fractures, enable correction of skeletal deformities or other related interventions. These devices are meant to share load with the bone during the healing a regenerative phase. These devices are subjected to various medical forces while in use. The extent to which the device would withstand these forces is limited by the operating surgeon achieving a stable fixation construct, the use of bone graft to supplement the fixation where appropriate, the correct weight bearing regimen prescribed by the operating surgeon based on the progress of healing and the compliance of the patient. These devices are meant to be removed after they have served their intended purpose.

#### **2. Material:**

The chrome-nickel-molybdenum alloyed austenitic stainless steel used for these devices complies with the international norm AISI 316L.

#### **3. Preparation:**

Before the operation, an operative plan must be drawn up by the operating surgeon, ensuring that –

All implant components necessary are available in the required quantities

Aseptic operating conditions are present.

The required set of instruments is complete, operable and compatible.

All pertinent documents related to the set of instruments and the implants being used are present and the surgeon and the operating team are, familiar with them.

The operating surgeon is experienced in performing internal fixation procedures to stabilize fractures using implants and in particular with specific operative procedure being performed, involving the use of the implant.

#### **4. Indication:**

Surgical Stabilization following operative procedures to treat fracture, enable correction of deformities or other related interventions, as per the latest fracture management / deformity correction, treatment protocols.

#### **5. Contraindications:**

Contraindications are the use of this device include but are not limited to the following:

Immunological intolerance

Patients displaying metal sensitivity or allergic reactions to any of the elements grade materials e.g. Nickel or Chromium

Presence of degenerative diseases

Mental illness

Alcohol and/or drug addiction

Obesity

Poor patient compliance



Expected overloading of the implants

## **6. Implant Selection and Handling.**

All implant components should be checked for intact packaging on receipt. In case a loaner or consignment set of instruments and implant components is used, all instruments and implants must be carefully checked for completeness and all components should be carefully inspected for absence of damage prior to use.

Selection of the proper size, shape, and design of the implanted device is a crucial parameter for success of the operative procedure and must be ensured by the operative surgeon.

For implants that need to be bent or contoured to conform to the shape of the bone, such contouring must be achieved using bending instruments specially designed for this purpose. Reverse bending which decreases the fatigue life of plates must be avoided. Care should be exercised to ensure that there are no scratches or distortions at the sites of plates holes and that the process of contouring does not cause notches or sharp dents on the implants which may predispose the device to failure.

All pre-operative handling on implants must be done with care to ensure that the handling does not cause scratches, notches or dents on the surface of the implants that may predispose the device to failure.

## **7. Sterilization:**

Unless specifically supplied pre-sterile and clearly labeled as such, all implant components and instruments must be sterilized prior to use in surgery using standard sterilization cycles and process parameters in accordance with the latest recommended standards and practices for sterilization of metallic implantable devices.

Some commonly used sterilization methods are: Steam sterilization with Gravity cycle at a temperature of 121 deg Centigrade with an exposure time of 30 minutes.

Or

Steam sterilization under Pre-Vacuum cycle at a temperature of 132 deg. Centigrade with an exposure time of 4 minutes.

Prior to sterilization, all packaging materials must be removed and the device should be cleaned. Only sterile implants and instruments must be used in surgery. All instruments and implants must be cleaned and dried immediately following use in surgery using standard procedures for cleaning of operative surgical devices.

### **Implants Removal:**

Bone Plates, Bone Screws, Intramedullary Nails, Pins and Wires are internal fixation devices. It is intended that these devices assist in the process of stabilizing the operative site during the normal process of healing.

Subsequent to healing, these devices do not serve any further functional purpose and need to be removed.

Removal is primarily indicated in most cases, as the implants are not intended to transfer or support forces applicable during normal activities. If the implant components are not removed subsequent to completion of their intended use, the following complications may ensue.

Corrosion combined with localized pain or tissue reaction.

Migration of position of the implant, resulting in injury.

Postoperative trauma with the risk of additional injury.

Bending, loosening and/or breakage of implants components, which may make removal more difficult or even Impractical.

Possibly increased risk of infection.

Bone loss due to stress shielding.

Pain, discomfort or abnormal sensation felt by the patient due to the presence of the device.

### **8. Important Information:**

The operative surgeon is responsible for carrying out the internal fixation procedure correctly and must have mastered the acknowledged updated and latest operating techniques related to the type of surgery being performed, in theory and practice. Complications due to incorrect diagnosis and operating technique and limitations of the method of treatment or lack of aseptic conditions are not the responsibility of the manufacturer.

In addition to physiotherapy and muscle training, it is the responsibility of the operating surgeon to educate the patient about the limitation of metallic implants and precautions to be followed to avoid unnecessary stresses to the implants. In case of devices such as pins and wires which while implanted, project outside the patients body, as a part of an external fixator assembly, it is also the responsibility of the operating surgeon to educate the patient on the possibility of pin tract infection and its associated problems the importance of maintaining general hygiene and methods of maintaining cleanliness and care of the projecting pins and wires and the external fixator assembly.

Detailed instructions must be given to the patient concerning the use and limitations of the implanted device. If partial weight bearing is required or recommended prior to bony union, the patient must be warned that loosening, bending or breakage of the device are complications which may occur due to early or excessive weight bearing or muscular activity. The patient should be warned to avoid falls or sudden jolts of any nature. If the patient is demented, debilitated or otherwise unable to use crutches or other supporting devices, the risk of loosening, bending or breakage may be increased. The patient must be made aware of this fact.

Any retrieved implant component should be treated in such a manner so as to render further use / re-use of the components, impossible. Used implants that appear undamaged may have internal and external defects caused through accumulated stresses while in use. Reuse of implants, predispose such implants to premature failure.

Implants components from one manufacturer should not be used with those of another. In case such combinations are necessary, they would be possible only if the surgeon can ascertain that all implants being used are manufactured to correct dimensional specifications and tolerances and from

chrome-nickel-molybdenum alloyed austenitic stainless steel complying with or compatible to the relevant standards referred to above.

- **Sterilization method for the ortho products.**

### **BARC**

Nail : Austin moore

### **ETO:**

FIXBIPOLER

ALL FEMURE STEM

ACETUBULAR CUP

BIPOLAR HEAD

MODULAR BALLS

All the other items are for Autoclave sterilization.

### **What is Austin Moore Prosthesis?**

Austin Moore Prosthesis is used when the femoral head is broken; this prosthesis consists of a round solid ball with a tail having holes. The broken femoral head is taken out and is replaced by AMP. The tail rests in the femoral cavity. The size of the AMP depends upon the diameter of the femoral head.

### **When is Austin Moore used?**

The AMR is used when the femoral head is broken or fractured and cannot be united.

### **What is the Bipolar prosthesis?**

Bipolar prosthesis is used when the femoral head is broken from its neck. Bipolar Prosthesis consists of stem, modular ball, and bipolar head. It

provides better mobility than the conventional Austin Moore prosthesis because it provides additional movement between stem and head. The stem is fixed in the femoral cavity with the help of bone cement.

### **What is total Hip prosthesis?**

Total Hip Prosthesis is used when the acetabular cavity is damaged. Artificial acetabular cup is fixed in the broken cavity. Total Hip Prosthesis consists of Acetabular cup, stem, and modular ball.

### **What is cemented Hip prosthesis?**

In this type artificial Acetabular cup is fixed in the broken Acetabular cavity with the help of bone cement. The stem is cemented in the femoral cavity.

Fixed Bipolar for femur neck fracture 39 – 53 mm.

### **What are K wires?**

K wires are the S.S wires of various diameters used for reduction and for holding the small fractured segment. It pointed on both the ends. Sometimes it is used as a guide to direct a screw.

### **What are Guide wires?**

Guide wires are used in interlocking nailing system. Their main application is to guide the passage of the nail in the medullar cavity.

### **What are Stienmen pins?**

**Stienmen pins are used as external fixator.**

### **Schanz pins:-**

Schanz pins are external fixators, its pointed end is inserted in the bone, its thread provide better grip in the bone. The other end is passed through the clamps and the clamps are attached to each other with the help of rods and the bone union is achieved.

**Modular Bipolar:-**

Stem length – 90,120,130, 140.

Ball-22mm,3.5mm,

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This plate is available in the angles of 120, 125, 130, 135, 140, and 145 and in sizes depending on the number of screw holes.

**What is DCS Plate (Dynamic Condylar Screw)**

This plate is used for the condylar fractures in the femur. The angle of the plate is from 4 holes to 12 holes 95° and the same DHS top screw is used.

**What are types of DCS plates?**

DCS plates are available in round as well as DCP holes.

## **What are the various Bio-fixation plates and their uses?**

The various plates are 2 to 5 holes radius fracture, L Plates, Y Plates, 4 to 7 holes meant for lower tibia fracture, T –Buttress Plate, Cobra Plate, 4-10 holes meant for upper tibia fracture.

## **What are the types of Screws**

Cortical Screws (3.5, 4.5 mm) used in Broad and narrow plating  
Cancellous screws (4 mm) with short threaded and fully threaded  
Cancellous screws (6.5 mm) with 16mm, 32mm, and fully threaded  
Cannulated Cancellous screws (4mm) with short threaded and fully threaded  
Cannulated Cancellous screws (6.5mm) 16mm, 32mm, and fully threaded

Cancellous Screws are used in CC Surgeries, plating and in interlocking.  
Self Tapping Bolt (3.5mm and 4.5mm) used in interlocking nailing.  
Malleolar Screws used in fixation of bone fragments.

## **What are Cortical screws**

Cortical screws are fully threaded. They are non-self tapping, hence tapping is required before insertion. They are available in two size's (3.5mm & 4.5mm) and length varies from 18 to 58 mm in step of 2mm. Cortical screw are widely used in plating. They are also known as cortex screws.

## **What are Cancellous screw**

Cancellous screws have a thin core and a wide and deep thread. It gives the screw considerable increased holding power in fine trabecular bone. They are fully or partially threaded having thread size 4mm & 6.5mm. Fully threaded screw are used in metaphyseal and epiphyseal areas of bone. Partially threaded screws are used as Lag screws.

What are Malleolar screws

Malleolar screw have the same thread profile like cortical screws but with a trephine tip. They are used for the fixation of medial malleolus. They are partially threaded and are ideal for fixation of bone fragment.

### **What are the size's of screws available**

PF screws – 6.5 & 8 mm used in Proximal locking 50 to 100

Cortical screws – 3.5mm length is (10mm to 40mm) (2mm difference)  
\_ 4.5mm length is (12mm to 60mm) (used in plating)

cancellous screws – 4mm with short threaded is (10mm to 75mm.) (5mm difference) and fully threaded is (10mm to 75mm.)  
6.5mm with short 16mm is (25mm to 110mm)  
(medium) 32mm is ( 35mm to 110mm)  
fully threaded is (10mm to 75mm.)

Self Tapping Bolt: 3.5mm length is (16mm to 50mm) (2mm difference)  
4.5mm length is (16mm to 70mm) (used in inter locking nailing)

Bio-fixation screw – 3.5mm for fracture of radius ulna Narrow \ broad 4.5mm.

Malleolar screws: 4.5mm (25mm – 100mm) (5mm difference)

### **What is DHS screw**

DHS screw is used as a top screw to DHS plate. It is passed through the barrel of the DHS plate. The thread is fixed in the femoral head at the center of the subtrochanteric region. The small screw locks the other end after the plate is fixed and the reduction is achieved. It is available in the length from 50mm – 110mm with 5mm difference.

### **What are sizes of DHS Screws?**



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**17/7/06**

Sterilization (or sterilization) is the elimination of all transmissible agents (such as bacteria, prions and viruses) from a surface, a piece of equipment, food or biological culture medium. This is different from disinfection, where only organisms that can cause disease are removed by a disinfectant.

### **Heat sterilization**

#### **Autoclaves**

A widely-used method for heat sterilization is the autoclave. Autoclave commonly use steam heated to 121°C (250°F), at 103 kpa (15 psi) above atmospheric pressure, for 15 minutes. The steam and pressure transfer sufficient heat into organisms to kill them.

Proper autoclave treatment will inactivate all fungi, bacteria, viruses and also bacterial spores, which can be quite resistant. It will not necessarily eliminate all prions (discussed later).

To ensure the autoclaving process was able to cause sterilization, most autoclaves have meters and charts that record or display pertinent information such as temperature and pressure as a function of times.

Indicator tape is often taped onto package of products to be autoclaved. The tape contains a chemical that will change color when the appropriate conditions have been met. Some types of packaging have built-in indicators on them. Biological indicators, (such as the Attests), can also be used. These contain *Bacillus stearothermophilus* spores, which are among the toughest organisms an autoclave, will have to destroy.

## **Ethylene Oxide**

Treatment of medical devices by ethylene oxide is one of the principal methods of sterilization in the healthcare industry.

### **Mode**

Ethylene oxide (C<sub>2</sub>H<sub>4</sub>O) is a gas at operating temperature and sterilize via its action as a powerful alkylating agent. Under the correct conditions, cellular constituents of organisms such as nucleic acid complexes, functional proteins and enzymes will react with ethylene oxide, causing the addition of alkyl groups. As a result of the alkylation, cell reproduction is prevented and cell death ensues. In order to achieve this effect, certain conditions must be achieved at the site of sterilization within the products. These include an adequate concentration of ethylene oxide and a necessary level of water activity within the organism. Since the process is a chemical reaction it is temperature dependent, with the rate of reaction increasing with temperature. These properties define the key characteristics of an ethylene oxide sterilization process.

### **Process**

Finished, packaged product received from customers is processed on pallets. Initially the load is raised to the required temperature and moisture content via a two stage pre-conditioning procedure that lasts approximately 24 hours. Final temperatures are typically between 40°C and 60°C with relative humidity levels of 45% - 75%. Having achieved the necessary temperature and humidity, the load is then transferred into the sterilization chamber. The stainless steel sterilization chamber is evacuated to remove air, steam is injected to the chamber to re-establish the necessary moisture content, and ethylene oxide is then introduced until the required concentration is achieved.

The chamber itself is heated by circulating hot water through a surrounding jacket, maintaining temperature typically within +/-1°C of the target temperature. Circulation fans within the chamber ensure rapid and uniform distribution of ethylene oxide right through into the centre of the load. Product is held under these conditions for a defined period, typically 2-4 hours. Any loss of ethylene oxide from the chamber is exhausted to the atmosphere via a catalytic converter. This unit ensures catalytic conversion of ethylene oxide to carbon dioxide and water typically with efficiency greater than 99.9% ensuring that emissions from the chamber remain within internationally accepted environmental limits. The sterilization chamber and its contents are then repeatedly flushed with nitrogen or air to remove the remaining ethylene oxide from the chamber. Air pulsing and vacuum hold is also available to accelerate removal of ethylene oxide. After completion of post sterilization flushing, products is transferred to an aeration cell where it is subjected to high rates of air change at temperatures close to the sterilization temperature for approximately 12 hours. This phase of the process serves to further scavenge residual ethylene oxide from product and packaging. The exhaust from this phase is also treated via the catalytic converter. On completion of initial aeration, product is transferred to a secondary aeration area where an optional additional period of elevated temperature storage can be used to further reduce residual ethylene oxide levels. This takes place at 25°C to 35°C typically for up to 7 days and is available for those manufacturers whose products may benefit from this treatment.

Stainless Steel – Grade 316L – Properties, Fabrication and Applications

Chemical Formula

Fe, <0.03%C, 16-18.5%Cr, 10-14%Ni, 2-3%Mo, <2%Mn, <1%Si,  
<0.045%P, <0.03%S

## **Topics Covered**

### **Background**

### **Key Properties**

#### **Composition**

#### **Mechanical Properties**

#### **Physical Properties**

#### **Grade Specification Comparison**

#### **Possible Alternative Grades**

### **Corrosion Resistance**

### **Heat Resistance**

### **Heat Treatment**

### **Welding**

### **Machining**

### **Hot and Cold Working**

### **Hardening and Working Hardening**

### **Applications**

### **Background**

Grade 316 is the standard molybdenum-bearing grade, second in importance to 304 amongst the austenitic stainless steels. The molybdenum gives 316 better overall corrosion resistant properties than Grade 304, particularly higher resistance to pitting and crevice corrosion in chloride environments.

Grade 316L, the low carbon version of 316 and is immune from sensitization (grain boundary carbide precipitation). Thus it is extensively used in heavy gauge welded components (over about 6mm). There is commonly no appreciable price difference between 316 and 316L stainless steel. The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures.

Compared to chromium – nickel austenitic stainless steels, 316L stainless steel offers higher creep, stress to rupture and tensile strength at elevated temperatures.

### **Key Properties**

These properties are specified for flat rolled product (plate, sheet and coil) in ASTM A240/A240M. Similar but not necessarily identical properties are specified for other products such as pipe and bar in their respective specifications.

### **Composition**

Table 1. Composition ranges for 316L stainless steels.

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	N
316L	Min	-	-	-	-	-	16.0	2.00	10.0	-
	Max	0.03	2.0	0.75	0.045	0.03	18.0	3.00	14.0	0.10

### **Mechanical Properties**

Table 2. Mechanical properties of 316L stainless steels

Grade	Tensile strength (Mpa) min	Yield strength 02.% proof (Mpa) min	Elong (% in 50mm)min	Rock well B (HR) max	Brines (HB) max
<b>316L</b>	<b>485</b>	<b>170</b>	<b>40</b>	<b>95</b>	<b>217</b>

### **Physical Properties**

**Table 3. Typical Physical properties for 316L stainless steels**

Grade	Density kg/m <sup>3</sup>	Elastic Modulas (Gpa)	Mean Co- eff of Thermal Expansion (um/m/°c) 0-100°c 0- 315°c, 0- 538°c	Therm al conduc ting (w/mk) At 100°c At 500°c	Specific heat 0- 100°c(J/ kg k)	Electric Resistivi ty (nm)
316L	8000	193	159 162 175	163 215	500	740

**Grade Specification Comparison**

**Table 4. Grade specification for 316L stainless steels**

Grade	VNS	Old British		Euronom		Swedish	Japanese
	NO	BS	En	No	Name	Ss	JIS
316L	531603	316511	-	1.4404	X2CrNi Mo17- 12-2	2348	Sus 3161

Note: These comparisons are approximate only. The list is intended as a comparison of functionally similar materials not as a schedule of contractual equivalents. If exact equivalents are needed original specifications must be consulted.

**Possible Alternative Grades**

**Table 5. Possible alternative grades to 316 stainless steel.**

Grade	Why it might be chosen instead of 316?
316L	Higher resistance to chlorides than 316L, but with similar

resistance to stress corrosion cracking.
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### **Corrosion Resistance**

Excellent in a range of atmospheric environments and many corrosive media – generally more resistant than 304. Subject to pitting and crevice corrosion in warm chloride environments, and to stress corrosion cracking above about 60°C. Considered resistant to potable water with up to about 1000mg/L chlorides at ambient temperatures, reducing to about 500mg/L at 60°C.

316 is usually regarded as the standard “marine grade stainless steel”, but it is not resistant to warm sea water. In many marine environments 316 does exhibit with crevices and rough surface finish.

### **Heat Resistance**

Good oxidation resistance in intermittent service to 870°C and in continuous service to 925°C. Continuous use of 316 in the 425-860°C range is not recommended if subsequent aqueous corrosion resistance is important. Grade 316L is more resistant to carbide precipitation and can be used in the above temperature range. Grade 316H has higher strength at elevated temperature and is sometimes used for structural and pressure containing applications at temperatures above about 500°C.

### **Heat treatment**

Solution Treatment (Annealing) – Heat to 1010-1120°C and cool rapidly. These grades cannot be hardened by thermal treatment.

### **Welding**

Excellent weldability by all standard fusion and resistance methods, both with and without filler metals. Heavy welded sections in Grade 316 require post-weld annealing for maximum corrosion resistance. This is not required for 316L.



316L stainless steel is not generally weldable using oxyacetylene welding methods.

### **Machining**

316L stainless steel tends to work harden if machined too quickly. For this reason low speeds and constant feed rates are recommended.

316L stainless steel is also easier to machine compared to 316 stainless steel due its lower carbon content.

### Hot and Cold Working

316L stainless steel can be hot worked using most common hot working techniques. Optimal hot working temperatures should be in the range 1150-1260°C, and certainly should not be less than 930°C. Post work annealing should be carried out to induce maximum corrosion resistance.

Most common cold working operations such as shearing, drawing and stamping can be performed on 316L stainless steel. Post work annealing should be carried out to remove internal stresses.

### **Hardening and Work Hardening**

316L stainless steel does not harden in response to heat treatments. It can be hardened by cold working, which can also result in increased strength.