SHAPA Technical Bulletin No. 1

Guide to the Selection of The Surface Finish of Stainless Steel on Fabricated Items

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1.0 Introduction

The specification of a surface finish for equipment that is fabricated from stainless steel is a source of many potential problems and misunderstandings between purchasers and manufacturers. The implications for costs and ‘like for like’ comparisons between tenders, and the need to establish that the equipment condition satisfies all functional requirements of the application, dictate that the surface finish specified should be clearly and appropriately defined in all contractual documents. Unqualified descriptions, such as 'crevice free' or 'polished 400 grit', may appear definitive, but all to often these lead to ambiguities, disagreements of interpretation, or an unfitness for purpose.

No standards exist for the finish of fabricated stainless steel items. This may well be because it is complex and difficult to produce one that will unambiguously satisfy suppliers and customers.

2.0 Standards Relevant to Surface Finish

Two standards that are concerned with the production of specimen pieces that are to be used as a reference against which production items will be compared are: -

BS 2634 **Part 1** 1987 (ISO 2632/1 - 1985) (machined methods)

Roughness Comparison Specimens - for turned, ground, bored, milled, shaped and planed specimens

Part 2 1987 (ISO 2632/2 - 1985) (surface finishing methods)

Roughness Comparison Specimens – for spark eroded, grit basted and polished specimens.

Standards related to the production of specimen pieces against which the finish of a flat surface may be compared are: -

BS 1134 - Assessment of Surface Textures.

Part 1 1988 - Methods & Instrumentations.

(This standard describes methods for the assessment (measurement) of surface texture of various finishes. It is very technical and detailed, but does not specify different grades of finish.)

Part 2 1990 - Assessment of Surface Texture.

(This standard gives general information and guidance on the method of assessing surface texture given in part 1. Appendix A.4.1. in the standard is useful as guidance on how many readings to take).

BS 1449 **Part 1.** 1991 Sections 1.1 to 1.15 replaced by EN 1088

(This standard specifies the properties of various stainless steels, and includes a general reference to surface finish of six mechanically polished surfaces of different nom. grit sizes..

Part 2 1983

(Amended in 1985 and 91 and 683/13 Euronorm 88)

Nom Grit size.	BS 1449 Pt. 2.	En 1088 – 2	Description
80 – 100	3A	1G/2G	Ground Ra nom 2.5 μm
180	3B	2J	Ground Ra nom 1.25 μm
240	4	1J/2J	Dull Polish nom 0.6 μm
320	5	1K/2K	Satin Polish Ra >0.5 μm
590 – 630	7	2P	Bright Polish Ra nom 0.05 μm
800	8	1P/2P	Mirror Finish Ra nom 0.05 μm

ANCI/ASME **B 41.1.** 1985 Surface Textures.

(This is similar to BS 1134 Part 1, but with even more technical detail)

ISO 8785-1998 Geometric Product Specification

ISO 4287 Geometric Product Specification – Surface Texture

3.0 Surface Finish Selection

In the absence of a specified standard relative to the fabricated component, the selection of a surface finish may be made on the basis of choosing the optimum economic manufacturing process that will produce a surface adequate for the duty. Narrow functions of crucial importance may dominate this decision, as with accommodating fatigue problems or meeting stringent hygenic requirements. The choice may be compromised by global conditions, such as that of seeking uniformity in a multi-component machine, or for all machines in a plant to have a matching appearance

A useful starting point is to review the differing criteria on which the specification of surface finish is based. This illustrates the many-attribute nature of the situation and how these may apply individually or in varied combinations, according to the application circumstances. The reason for selecting a particular surface finish usually relates to one or more of four basic considerations, **-**

1 - Appearance 2 - Performance 3 - Product and/or 4 - Plant

Under these headings the surface roughness ranges of production processes may be considered, as in the table, appendix. 1.

3.1 Appearance

The most common reasons for preparing a machine to a particular standard of appearance are: -

3.1.1 Cosmetic

A cosmetic finish is given for superficial appearance, for decoration or to conceal blemishes. Highly polished parts give a superficial impression of quality and purity, emphasising the nature of the material of construction, but do not necessarily represent the implied standard of detail finish. Bright polished panels or covers that are easy to fabricate without scratching, enhance the presentation of an otherwise uninteresting product. It is also undertaken to remove unsightly manufacturing and constructional marks to prevent the user viewing the item as a crude fabrication. It is common to acid clean and wire brush welded parts, to remove weld discoloration and to blend in Softened & De-scaled or 2B finish surfaces.

It must be recognised that the finish of a cold rolled 2B stainless steel surface cannot be replicated by mechanical polishing. A separate agreed specification must therefore be defined for welded parts of assemblies that are categorised as 2B finish. Likewise the treatment of scratches or other surface blemishes should be predetermined. Cosmetic finishes are not usually subjected to close scrutiny. An examination distance of one metre or more may be considered appropriate for fixed plant items. Superficial blemishes within complex fabricated shapes are unlikely to be detected or objectionable in these circumstances.

One approach to minimise minor damage during handling and fabrication is to apply a plastic coating to the mill sheets, prior to delivery to the equipment manufacturer. This protective film may be removed at a late stage of equipment construction. To some extent this coating inhibits cutting and welding processes, as laser or plasma profiling of the covered sheets causes edge fusion of the plastic. An extra dressing process is then required to secure a clean edge for welding.

The marginal cost of securing a bright polish on simple fabrications may not be high when bright polished sheets can be used with little forming or welding, hence a surface finish specification may be enhanced for cosmetic effect, or other reasons, at relatively little cost. Chemical treatment may be used to modify the protective passive oxide film to produce textured or coloured surfaces to enhance the decorative appeal of the surface. Certain finishing techniques, such as bobbin polishing that introduces an strong visual pattern on the surface, have the added useful function of distracting the eye from identifying minor blemishes or unevenness in the fabrication.

3.1.2 Uniformity

Where a machine or component is to form part of an integral assembly it is usual to blend all sections of the composite equipment to a common appearance. This essentially requires visual alignment of the surface textures and finish, to avoid detraction from an overall appearance of quality. Generally this requires the concealment of manufacturing scratches and blemishes, weld and burning discoloration and planishing marks. Bright, or mirror finish sections may be utilised, to command attention and draw the eye from constructional details and edges, which may be left unwelded to avoid distortion and discoloration.

3.1.3 Conformity

Plant consistency, in line with the user companies policy or image, is served by new equipment having similar grade of appearance with that previously installed. This matters in situations where the perception of quality, purity, and hygiene, are important to the reputation of the user, for example in dairies, food factories and pharmaceutical plants.
Manufacturers Standard

3.1.4 Manufacturers or users quality of finish

A specific quality of finish may be set by the manufacturing company or by the user. Manufacturers offering equipment to industries that expect a particular standard of finish may implement a policy of preparing to a set finish, regardless of the use to which the equipment is finally put. This may be cosmetic, for sales presentation purposes, or to offer flexibility for different applications. For example, a feeder manufacturer offering a form of machine designed to have universal appeal may decide to adopt a uniform quality of surface finish that meets a range of application objectives. The pleasing appearance not only reflects the quality of construction, but also is able to satisfy easi-clean and hygienic finish, corrosion and stress resistance, non-contamination and good surface slip properties within a common specification, although some of these attributes may not be essential on every application.

3.2 Performance

Apart from resisting corrosion, wear and offering a hygiene surface, stainless steel influences the operational performance of solids handling plant as below: -

3.2.1 Surface slip

Hoppers, chutes and screw feeder blades all require relative motion between the contact surface and the material handled. The performance of a feeder depends upon the equipment mechanics, and surface friction is a key design parameter for screw feeders, hoppers and chutes. Surface slip determines the effectiveness of the flights in moving the material, and thereby influences the extraction pattern from the supply hopper.

The design procedure for determining the wall inclination needed to secure mass flow in conical and wedge shaped hoppers is based mainly upon wall friction tests. For hoppers that are not of mass flow type, wall friction is important in relation to the slope at which the material will slide clear of the walls to empty the hopper.

Frictional values are fundamental to the performance of all bulk handling equipment. Being are simple to undertake, these measurements should be an integral feature of any specification relating to a solids handling contract. The procedure for measuring wall friction is given as an addendum in the I.Chem.E publication “Standard Shear Cell Testing Technique using the Jenike Method”.

A specified wall friction value for a given surface finish must relate to a well defined bulk product as there is no correlation between a particular surface finish and differing bulk materials for slip behaviour. For example, 2B finish may offer superior sliding properties to an electropolished surface with one material, but higher resistance for a different bulk product, or even for the same product with a different moisture content. Quantified values with the relevant combination of contact materials are essential, and the acceptable bounds of variation of the bulk material properties must be specified with precision.

3.2.2 Surface release properties

A smooth surface tends to discourage the adhesion of cohesive, damp, wet or fatty solids, although when the avoidance of such behaviour is important, the surface cohesion of optional surfaces should be measured by tests. Surface cohesion is shown on a wall friction graph, where the force promoting slip is plotted verses the normal load. The intercept on the slip force axis shows the measure of surface cohesion. A bright polished surface is not normally required for surface cleanliness or to prevent the adhesion of particles, in fact it may even be adverse.

In addition to interest in the metal surface and bulk product interface, specialised surface treatments, such as bonded dry-film lubricants, may be applied to improve lubrication and/or avoid seizing or galling. Other finishes offer an improved surface for soldering, or to minimise bi-metallic contact corrosion. The use of a preparation or superimposed finish would require separate approval for the specific application or industry, such as FDA approval.

3.3 Product

Consideration of the product places certain demands upon the contract material relative to quality, operating convenience, such as: -

3.3.1 Easi-clean

Equipment that has contact with differing or incompatible products, as with different coloured pigments, flavours and spices, pharmaceuticals or pure chemicals, often require to be thoroughly cleaned between applications, either regularly or on a campaign basis. Washing or steam cleaning carry the requirement that the material is impervious to water to avoid rust stains or contamination.

For ease of cleaning the surface must be smooth and with an absence of cracks or crevices. Continuous welding of parts, such as butt, angle and tee joints, may be adequate for some applications, but when the components have to be scrupulously cleaned to avoid cross contamination, again a ‘crevice free’ finish may be specified. Associated with the ease of cleaning is the need to verify that there is no prospect of cross contamination. Visual inspection is simplified when the absence of surface irregularities permits easy confirmation of the thoroughness of the cleaning process. The integrity of a ‘Crevice free’ finish, specified to avoid cross contamination, can be verified by a dye penitrant test.

The overall machine design plays a large role in determining the degree of access for both the verification of cleanliness and for the cleaning process itself. There may be a trade-off between the grade of finish chosen for the parts of the equipment and the need for more thorough access, the use of C.I.P, or even of having to dismantle the equipment for cleaning.

3.3.2 Sanitary

Hygiene criteria apply in many food handling and pharmaceutical situations, where the growth of bacteria or fungi in cracks, crevices and inclusions is a serious hazard to health. The relevant scale and effects are not visible to the naked eye, hence a testing process for cracks, such as dye penetration, is essential to verify the standard of surface finish. There are no great problems in achieving a hygienic surface on a smooth and continuous sheet surface. Greater difficulties arise with welded butt joints, and more so with concave and square welded joints. As a minimum the welds should be continuous. Argon welds are sometimes used to present a well penetrated, if rippled, surface. Recommendations from the European Hygienic Equipment Design Group (EHEDG) and the United States 3A Sanitation state that a Surface finish value of less than 0.8 μRa is suitable for food product contact surfaces. A higher Ra value may be acceptable if suitable ‘cleanability’ can be demonstrated.

For some applications handling foodstuffs or organic materials, the continuous welding of all parts that are in contact with the product may provide adequate hygiene standards for welding. Regular cleaning, washing down or sterilising, in these circumstances, can suffice for normal operation. Sterilised or washed components may require drying before re-use, and a smooth surface offers an easier surface to dry.

For more stringent duties, such as handling fish, meats and dairy products, and where there are extended periods of operation between cleaning, the welds should be ground and polished ‘crevice free’. The unqualified definition of ‘crevice free’ is, not uncommonly bandied about in an ambiguous manner and is subject to many interpretations. A definition of a ‘crevice’ is given in ISO 8785, fig. 7. When specified for sanitary purposes, 'crevice free' welds should be ground to a smooth corner fillet, or polished to form a continuous smooth surface of the same standard as adjoining metal. There should be no cracks, crevices, inclusions, weld splatter or irregularities which show when subjected to dye penetration testing. A degree of undercutting from the dressed weld into the parent metal is almost inevitable, but permissible, so long as the surface is smooth. This is a reason why this finish is not readily compatible with welded fabrications of thin metal construction, such as 16 swg. and thinner.

Argon welding deposits less material than electric arc and does not offer sufficient mass to secure grind away to a smooth, generous radius for a ‘crevice-free’ finish. Likewise, fusion welding, for orbitally welded pipes, introduces no filler material at the joint. Recommendations for welding stainless steel to meet hygienic requirements are given in EHEDG Document 9. The specification of a 'crevice free' finish does not necessarily imply a highly polished surface. The surface finish in terms of fineness of grit used is a separate issue to the absence of crevices, and this should be clearly brought out in any specification of this nature.

3.4 Plant - Machine integrity

3.4.1 Wear Resistance

For aggressive wear applications a wear resistant deposit can be welded or flame applied to the surface. One technique analogous to ‘wear boxes’ on chutes is to lay spaced parallel runs of hard weld deposit at right angles to the flow of bulk material on a contact face in solids handling equipment, to capture ‘fines’ in the spaced pockets. A thin bed of the material being handled then presents a layer of like material as a working face. However, the surface slip behaviour on the screw face is then a factor of the internal friction of the material, rather than of a smooth metallic interface.

Ion implantation and PVD (physical vapour deposition) can be applied to improve surface hardness. Metal sprays are also used to deposit a hard-wearing surface, or sometimes to roughen the surface, to resist wear by preventing surface slip. Austenitic stainless steels cannot be hardened by heat treatment, but are strengthened by cold working, and they retain good ductility and toughness even at high strength. Shot peening of the working face is therefore used to harden the surface. The shallow surface ‘skin’ that is compacted in this manner induces a compressive stress in the boundary layer of the material to give the surface better resistance to wear. Work input to the material during peening tends to relax inherent stresses due to forming and welding. Combined with the surface layer compressive stress, fatigue resistance is improved, as described later.

A virtue of stainless steel as a base material of construction is that the properties persist throughout the material so that, unlike coated finishes, the resistance to contamination or reaction with the product is not affected by wear, scratches or damage.

3.4.2 Corrosion

Corrosion can have many forms, for which different finishes are appropriate. -

3.4.2.a Pitting Corrosion

Austenitic stainless steels owe their corrosion resistance to the formation, from the Chrome (Cr), content of the steel, of a passive layer of chromium oxide on the exposed surface. Pitting occurs when the protective oxide film breaks down in small, isolated spots. The rate of attack tends to increase because of the differences in electric potential between the large surrounding passive surface and the active pit. This action is accentuated by the presence of saline solutions. A smooth surface, free of sensitive local minute pits or small depressions, reduces the potential for pitting to commence. The most appropriate quality of stainless for such duties should be selected.

The molybdenum (Mo), content of types 316 and 317 stainless resists the onset and development of pitting. The presence of Nitrogen (N), a strong Austenitic former, remarkably increases resistance to pitting and crevice corrosion. The relevant effect of Cr, Mo and N on crevice corrosion is denoted by the widely used PREN, Pitting Resistance Equivanlent Number.

PREN = Cr % + 3.3 Mo % + 16 N %

This indicates that resistance of a stainless steel to pitting corrosion is increased as the proportion of these alloying elements is increased, but the influence of N is 16 times greater than the chrome content and of Mo 3.3 times greater. Typical values of common stainless steels are given below.

Spec.	PREN	Cr	Ni	Mo	C max.	Nmax
304L	18-20	18-20	8-10.5	0	0.03	0.1
316L	28	16-18	10-14	2-3	0.03	0.1
316NL	205-240	16-18	10-14	0.03-0.08	0.16	0.1

3.4.2.b Crevice corrosion

Whilst the quality of the stainless steel is the prime defence against corrosion, the presence of cracks and crevices allows stagnant residual pockets of aggressive substances to remain. These imperfections shelter local differences in oxygen concentrations associated with deposits on the metal surfaces, which cause progressive damage after superficial cleaning of the outside surfaces. The ambient conditions pertaining within a sheltered crevice may be totally different to unconfined surface conditions, allowing more aggressive corrosion conditions to be developed and sustained than apply to the outer surface. The propagation of cracks can be very rapid, especially intense in chlorine environments. Molybdenum bearing steels are used to minimise this problem. Cracks and crevices also present large surface areas for corrosion attack and may also lead to mechanical weakness in the component, should the local region suffer excess corrosion. The specification ‘crevice free’ finish may be called for to avoid such hazard, but the smoothness of the surface is not so crucial as for hygienic duties.

3.4.2.c Stress corrosion cracking

The above situation is greatly aggravated in circumstances where accelerated corrosion takes place under a combination of high tensile stress, and a corrosive environment. The presence of a crack invariable leads to points of stress amplification, and chloride environments are extremely aggressive in conditions of high stress. For these situations a high degree of surface integrity at a fine scale is essential. The grinding and polishing of corner welds, to blend in with the complete absence of stress raising conditions, is an essential step to counter the aggravation of stress corrosion attack. As with fatigue problems below, steps should be taken to reduce tensile stresses where practical. Type 317 with min. of 3.5 % Molybdenum is recommended for such duties.

3.4.2.d Galvanic corrosion

A battery effect is created when dissimilar metals are in contact in the presence of an electrolyte,. The flow of current causes one of the materials to corrode preferentially. In these conditions any metal in the galvanic series tends to suffer corrosion when in contact with a metal of more positive potential in the emf series. The other metal in contact will experience little or no corrosion. It is therefore important to know which material is most anodic (least noble). The composition of weld rods, bolts, other fastening devices and adjoining materials, must be compatible with the parent or contact material where there is potential for galvanic corrosion.

3.5 Fatigue failure

Most stainless steels do not have the fatigue resisting qualities of other types of steel. They are therefore vulnerable to cyclic and repetitive stress applications. Screw feeders in continuous operation soon accumulate a high number of stress reversals in the shaft, as a result of rotary bending, to bring the component into the range of fatigue sensitivity. The first line of defence is to ensure that the level of working stress is relatively low, by selection of a suitable tube or centre shaft for the span and torque to be accommodated. The second stage is to reduce stress amplification points. The root of any tiny crack or surface irregularity provides an effective stress concentration and offers a source for propagating a fatigue crack.

The surface condition of the screw is of major importance, and should be free from sharp included corners, cracks and imperfections. However, welded joints and connections that do not have full weld penetration shelter internal discontinuities similar to cracks, usually close to the metals surface. These also provide a weak region and stress concentrator, to create an origin for the propagation of a fatigue crack. The specification ‘crevice free’ in this case is not just relevant to the exposed or contact surface, but should be taken to affect the general construction with respect to internal flaws and cracks. These are only verifiable by radiography of the weld regions.

The use of a ribbon construction for the feeder flight significantly reduces the run of shaft exposed to the formation of cracks, therefore in sensitive cases may be considered a useful constructional method, other factors being compatible.

Shot-peening is used to alter the surface condition of stainless steel subjected to fatigue conditions. Essentially the imposition of extra surface stresses causes local deformation that re-adjusts the stress state within the region. This process relaxes high local stresses as induced by forming and welding. The subsequent creation of a thin layer of compacted steel introduces a residual compressive surface stress. Under usage conditions externally applied tensile stresses are offset by this inherent compressive stress, as a corresponding reduction of the maximum tensile stress level is achieved. It is only when the initial condition passes through equilibrium that the surface experiences an effective tensile stress. A characteristics of fatigue behaviour is that a small reduction in effective stress value at the crucial failure levels will transform the life potential of the component, in many cases extending the magnitude of the cyclic stress capacity to a useful or indefinite life. As tensile stress is the main culprit in stimulating fatigue failure the resulting reduction in value of the absolute tensile stress offers considerable extra effective strength to oppose the onset of fatigue failure, therefore allowing higher stresses to be accommodated, or a longer life secured.

3.6 Snag free

Applications such as screw feeders handling fibrous products require a finish smooth to the touch so as not to snag on the product. Surfaces or components that are manually handled for routine dismantling or cleaned by hand, also require the contact parts to have a satisfactory 'feel' or texture. On surfaces against which loose solids are required to slide, minute snags or imperfections tends to present a key or foundation, on which a subsequent build up takes place to causes excess residue or even a blockage. Details of grit size and surface flatness tend to be secondary to the treatment of welded junctions and the smoothness of exposed edges, except in the cases of a cosmetic finish.

4.0 Surface Finishing Methods

Many finishing techniques are available to meet these differing requirements. In some instances a compound finishing process may be necessary to satisfy requirements that cannot be met by a common process. The most appropriate surface finish for a particular duty, and the method by which this is attained, are easier to determine and achieve when the objective for specifying of a particular finish is clear. To prepare goods to a stated finish without knowing the reason for its selection may well result in preparing the surface a more stringent specification than is needed for the application, with the consequent expenditure of more time and money than necessary.

A range of surface finishing techniques is available to meet the above needs. These include -

Mill finish	Softened and de-scaled (S & D), cold rolled (2 B), dull polished, bright polish and mirror finish.
Mechanical polish	Various grit finishes. Coarse to fine for differing degrees of smoothness.
Blasting	Varied media are used, such as sand, glass and plastic beads. An alternative to the construction from pre-polished sheets and mechanical polishing after fabrication is to bead-blast the entire stainless parts after fabrication, to bring all the surfaces to a common, pleasing appearance. One drawback of bead blasting is a tendency to 'fingermark'; hence some discretion is needed for its use on visible exposed surfaces that will be handled. Alternative blasting media are used to secure differing surface appearances and textures
Etching	Acid and wire brushing, normally for local treatment. E.g. welds.
Electropolish,	This is a process of surface 'de-plating' to expose virgin material. For this post manufacturing technique of 'electro-polishing' the entire component is placed in a de-plating bath and a surface layer of metal removed by electrolysis in a reverse manner to elecro-plating.
Cleaning techniques	A range of methods are used for the manual cleaning of stainless steel, as listed in Appendix. 2.

5.0 Summary

The selection of a particular material of construction and finish may be made for a variety of reasons. Whereas material identification is verifiable with material certificates, unless the required finish is set out with some precision there are many prospects for ambiguities and misinterpretations to arise. The attainment of some surface finishes is more cost sensitive than that of others, so the interests of both manufacturers and users are served by agreeing on a surface finish that is adequate, but not over-qualified for the duty in hand. Likewise, aspects of global finishes may require separate consideration to the treatment of blemishes or local ‘blending-in’ of deviations. In general, smother texture and a better surface quality involves higher costs

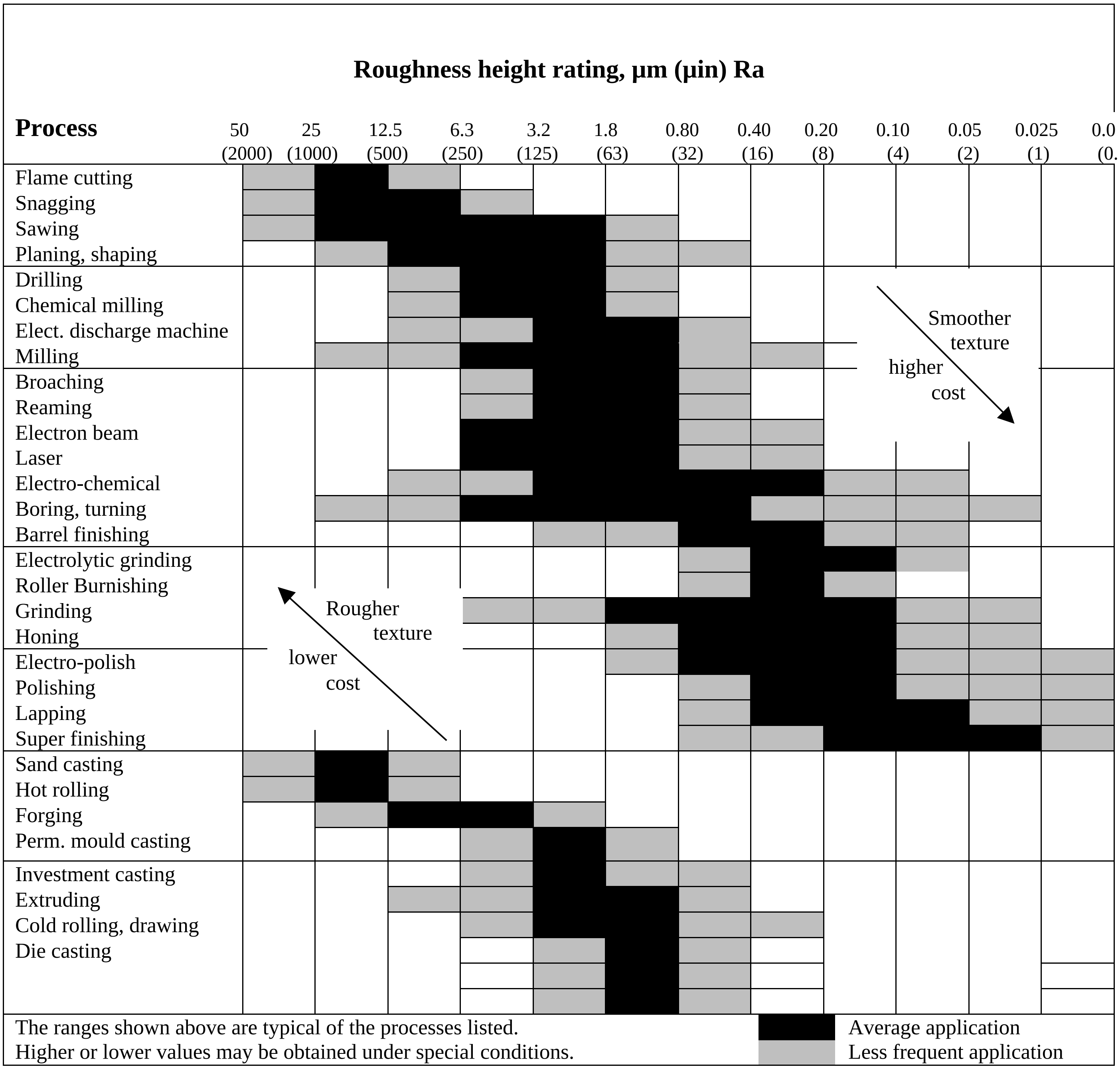
One of the more difficult features to quantify in detail is welded joints and assemblies. A common way to indicate the quality of finish on welded stainless steel components is by the provision of small examples. It is comparatively easy to achieve any required finish on a small component that is fully accessible and manoeuvrable, but quite a different matter to attain the same quality over every minute region of a large and complex fabrication.

To remove subjective judgement as far as practical from the inspectors task it is useful to have examples of both a specified finish, and one of a slightly lower grade of finish, with examples noted of what is not acceptable at any point of the final equipment, for comparison purposes.

A specification that identifies the basis on which a particular surface finish is selected will aid the manufacturer to determine the appropriate construction, and provide some guidance on the method by which it is attained. Perhaps of equal importance, it will focus attention on details of the equipment design that are important to secure the objectives sought by the specification of a particular surface finish. The function of the designer is to match these attributes with other performance related features of the equipment, and from these directions produce a blend of mechanical and geometric construction with surface finish that meets the full requirements of the installation.

The designer must also reconcile considerations of surface finish with constructional features of the equipment, such as ledges and cavities resulting from assembly limits for the fitting of parts. Consideration should be given to the presence of bolts and other abutments projecting from surfaces. Smooth contours and large radius corners present an appealing surface, aid cleaning and resist fatigue hazards.

The ultimate criteria is fitness for purpose but, as there are many different aspects to be satisfied, it may be useful to have a systematic and comprehensive sequence of headings to address, as in this guide, so that miss-applied specifications of surface finish are not reached by default.



Appendix 1 - Surface-Roughness, Range of Production Techniques

Problem	**Corrective Surface Treatment**	**Comments**
Routine cleaning of all finishes	Soap, ammonia or a detergent in warm water. Sponge with cloth, then rinse with clear water and dry. Where disinfectant is also required, a bactericidal detergent, such as 'Odourless Shield' should be used.	Satisfactory for use on all finishes of stainless steel
Fingerprints	Soap and water or an organic solvent (e.g. Usher-Walker Thinners No. PF 8017, acetone, iso-propyl alcohol, Genxlene.	Satisfactory for all finishes. Rinse with clean water and dry is necessary. Oil and wax cleaners can be used to minimise re-occurrence (e.g. Steel-clean, Johnson's Deep Gloss)
Oil and grease Marks	Organic solvents (e.g. acetone, alcohol, Geneclene-trichloroethylene, Usher-Walker Thinners No. PF8017 **(Do not use solvents in a confined area. No smoking, welding, burning or other exposed flames must be permitted in the vicinity during the treatment and for some time after)**	Clean with soap and water, rinse with clean water and dry. Where swabbing or rubbing is not practical use a 4-6 % solution of sodium metasilicate, a 4 % solution of tri-sodium phosphate, a 4 – 6 % solution of sodium pyrophosphate or a 4 – 6 % solution of sodium metaphosphate. Wash well
Stubborn stains or spots & other light discolouration	Mild abrasive cleaners (e.g. Jif, Ajax, Exoclean D 329, Goddard Stainless steel care. Try wet and dry emery, with detergent and water for stubborn stains	Scour lightly, rinse well with clean water and dry.
Hard water spots, & watermarks	Mild abrasive cleaners (e.g. Jif, Ajax, Exoclean D 329, Goddard Stainless Steel Care)	Scour lightly, rinse well with clean water and dry.
Tannin stains	Washing soda (sodium Carbonate) in hot water followed by washing in water or Chempro T	Satisfactory for all finishes
Engrained oily deposits	Baking soda (sodiun bicarbonate) in hot water followed by washing in water or Chempro T	An ammonia solution will remove heavy deposits.
Baked on carbon matter	Jif, Ajax Cream, Exoclean D329, Jonelle Houshold Cream	Heavy rubbing will leave a fine, scratched abraided surface finish.
Rust or other corrosion	Oxalic acid. The cleaning solution should be applied with a swab and allowed to stand for 15 to 20 minutes. Thoroughly wash with clean water. Use Jif, Ajax or similar for final clean.	**Strict precautions for acid cleaners should be observed. Rubber gloves, face mask and protective apron.** Do not use in a confined area.
Scratches on satin or No. 1 finish	For slight scratches use impregnated nylon pads or polish with scurfs dressed with iron-free abrasives. For deeper scratches, apply in direction of polishing, then clean with soap or detergent as routine cleaning.	Do not use ordinary steel wool. Iron particles can become embedded in the surface and rust to discolour later.
Heat tint, welding burns & heavy discoloration	Formula 9, Hi-Sheen, Stainless Steel Care, Duraglit or a similar silver polish. Alternatively acid clean and scour with a stainless steel wire brush. Wash copiously.	Heavy scouring may cause slight scratching or a light sheen over the area

Appendix 2 - Manual Techniques for Cleaning Stainless Steel

Precautions

Acids should only be used for cleaning when all other methods have been proven unsatisfactory. Rubber gloves, eye shield and aprons should be worn and care taken to ensure that acid is not spilt over adjacent areas. Special precautions and care are necessary with oxalic acids.

Solvents must not be used in enclosed spaces, and no smoking, welding, burning, grinding or naked lights should be permitted in the vicinity during, and for some time after, the treatment.