BE-102

Design & Engineering

Material Selection & Design Standards

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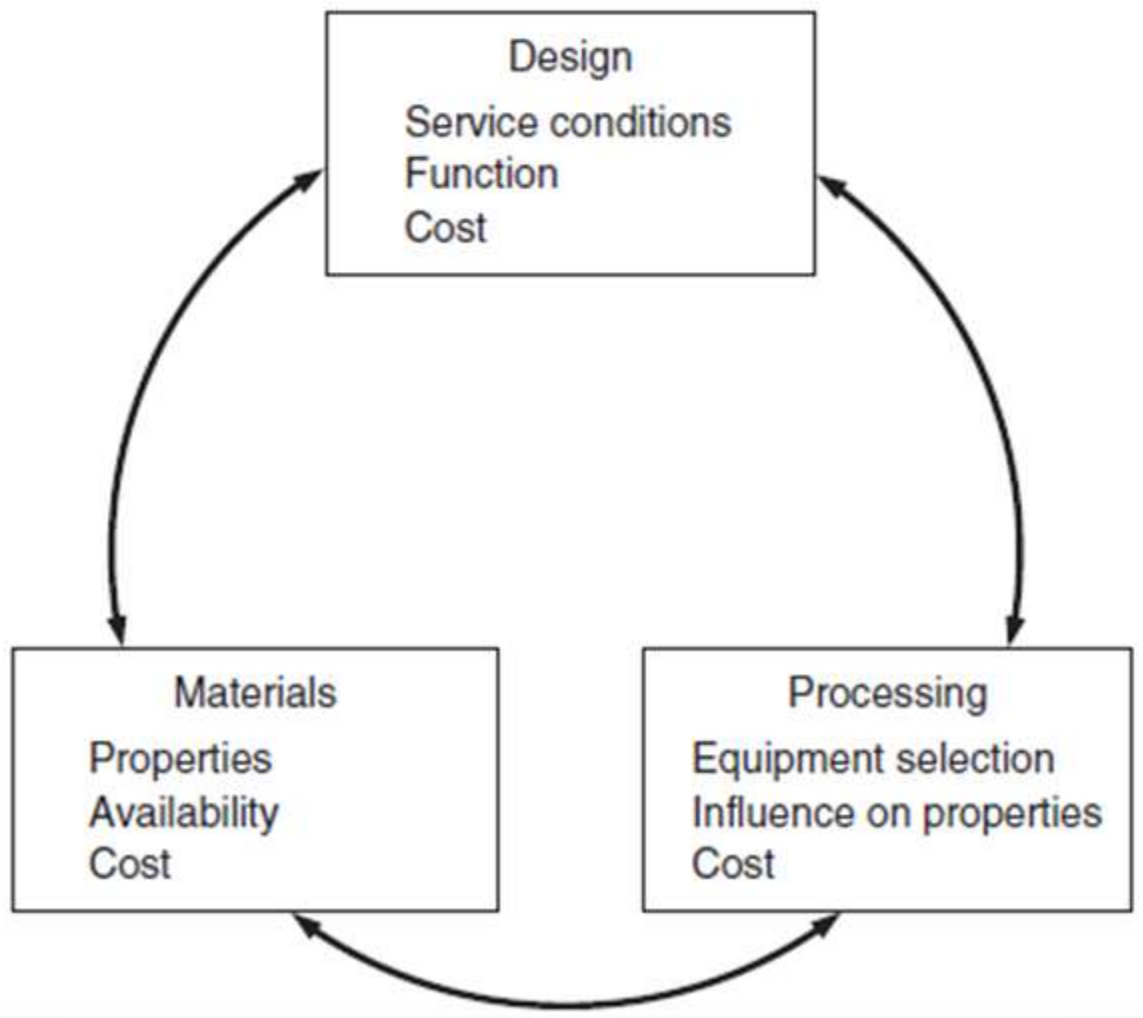
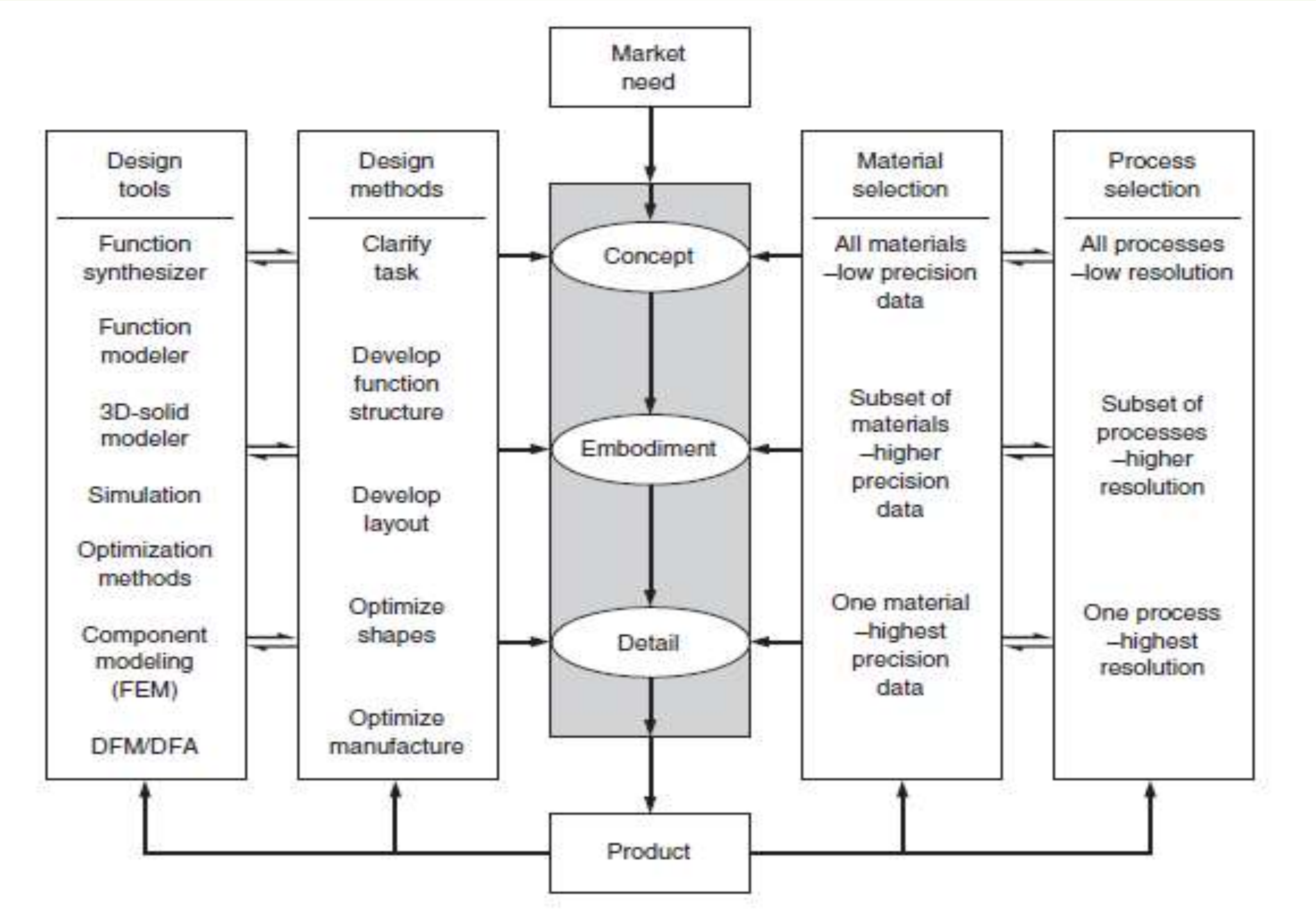
Material Selection

There are over 100,000 engineering materials to choose from. The typical design engineer should have ready access to information on 30 to 60 materials, depending on the range of applications he or she deals with.


Design
Service conditions
Function
Cost
Materials
Properties
Availability
Cost
Processing
Equipment selection
Influence on properties
Cost

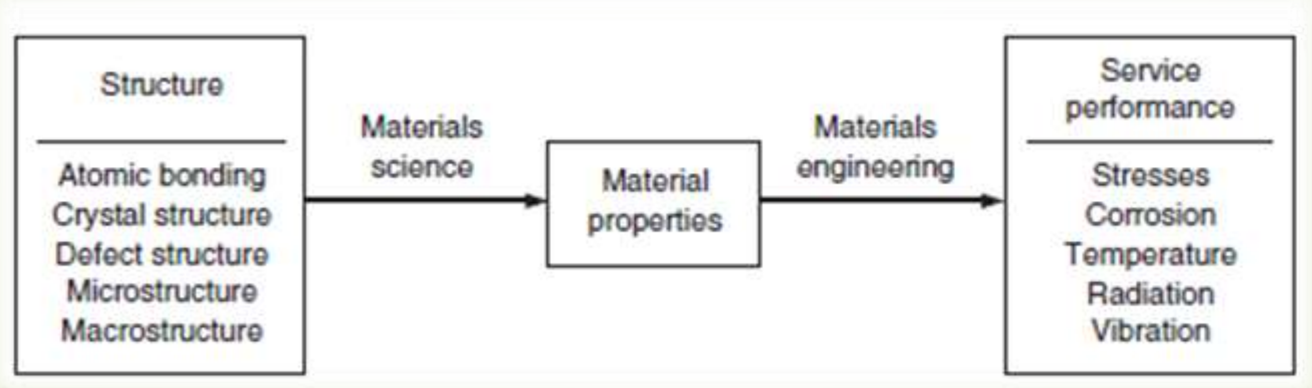
Material Selection Process



Material Selection Criteria

Materials are selected on the basis of four general criteria:

- Performance characteristics (properties)
- Processing (manufacturing) characteristics
- Environmental profile
- Business considerations



KINGDOM OF ENGINEERING MATERIALS

FAMILY
CLASS
SUBCLASS
MEMBER

METALS

Steels
- Plain carbon steel
  - AISI 1020
  - AISI 1040
- Alloy steels
  - AISI 4140
  - AISI 4340
  - AISI 8620
- Tool steels
  - O1 Oil hardening
  - H11 Hot work tool steel
  - M42 High-speed steel
- Cast irons
  - Gray iron, class 20
  - Ductile cast iron
- Stainless steel
  - AISI 304
  - AISI 316
  - AISI 440C

Aluminum Alloys
- 3003
- 6061
- 7075
- 380

Copper Alloys
- ETP copper-C1100
- Yellow brass-C36000

High-Performance Nonferrous Alloys
- Inconel 600 - Ni-Cr alloy
- Stellite - Co-Cr-W alloy
- Ti-6Al-4V

POLYMERS

Commodity Thermoplastics
- Polyethylene (PE)
- Polystyrene (PS)
- Polyvinyl chloride (PVC)

Engineering Thermoplastics
- Nylon 6/6
- ABS
- Polycarbonate (PC)
- Polyurethane(PUR)

Thermosets-highly crosslinked
- Alkyds
- Epoxies
- Phenolics
- Polyesters

Elastomers
- Rubbers
- Silicone resins

CERAMICS

Carbides, Oxides, Nitrides
- Alumina, Al_2O_3
- Silicon carbide, SiC
- Silicon nitride, Si_3N_4
- Toughened zirconia, ZrO_2

Cemented Carbides
- WC-6% Co

Carbon
- Carbon fibers
- Graphite

Building Materials
- Bricks
- Concrete

Glass

COMPOSITES

Wood

Fiber-Reinforced
- Carbon fiber-polymer matrix
- Glass fiber-polymer matrix

Laminated composite

A Short List of Material Properties

Structure-Insensitive Properties	Structure-Sensitive Properties
Melting point, T_m	Strength, σ_f, where f denotes a failure mode
Glass transition temperature, for polymers, T_g	Ductility
Density, ρ	Fracture toughness, K_{Ic}
Porosity	Fatigue properties
Modulus of elasticity, E	Damping capacity, η
Coefficient of linear thermal expansion, α	Creep
Thermal conductivity, k	Impact or shock loading resistance
Specific heat, c_p	Hardness
Corrosion rate	Wear rate or corrosion rate

Material Selection Criteria's

1.Availability

- Are there multiple sources of supply?
- What is the likelihood of availability in the future?
- Is the material available in the forms needed (tubes, wide sheet, etc.)?

2. Size limitations and tolerances on available material shapes and forms,

   e.g., sheet thickness or tube wall concentricity

3. Excessive variability in properties

4.Environmental impact, including ability to recycle the material

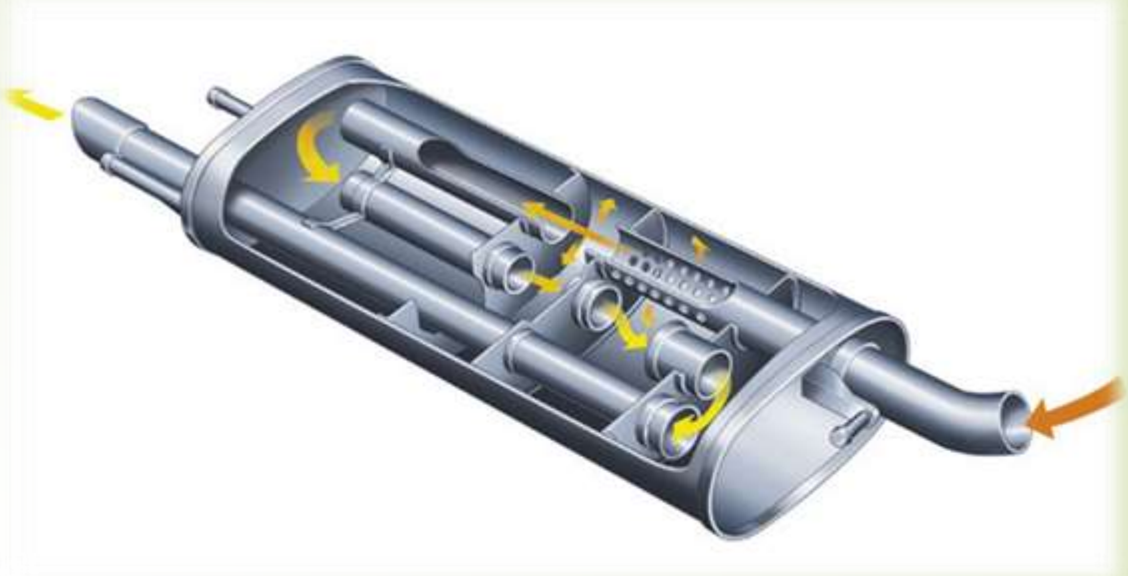
5. Cost. Materials selection comes down to buying properties at the best available price

Material Selection Example

Consider the question of materials selection for an **automotive exhaust system**. The product design specification states that it must provide the following functions:

- ✓ Conduct engine exhaust gases away from the engine
- ✓ Prevent noxious fumes from entering the car
- ✓ Cool the exhaust gases
- ✓ Reduce the engine noise
- ✓ Reduce the exposure of automobile body parts to exhaust gases
- ✓ Affect the engine performance as little as possible
- ✓ Help control unwanted exhaust emissions
- ✓ Have an acceptably long service life
- ✓ Have a reasonable cost, both as original equipment and as a replacement part

Material Requirements for an Automotive Exhaust System



Mechanical property requirements not overly severe.

- Suitable rigidity to prevent excessive vibration
- Moderate fatigue resistance
- Good creep resistance in hot parts

Limiting property:

corrosion resistance , especially in the cold end where gases condense to form corrosive liquids.

Properties of unique interest:

The requirements are so special that only a few materials meet them regardless of cost.

- Pt-base catalysts in catalytic converter
- Special ceramic carrier that supports the catalyst

Previous materials used:

Low-carbon steel with corrosion-resistant coatings.

Material is relatively inexpensive, readily formed and welded. Life of tailpipe and muffler is limited.

Newer materials used:

With greater emphasis on automotive quality, many producers have moved to specially developed stainless steels with improved corrosion and creep properties. Ferritic 11% Cr alloys are used in the cold end components and 17 to 20% Cr ferritic alloys and austenitic Cr-Ni alloys in the hot end of the system.

Why these materials are suitable for particular applications as mentioned bellow

Rubber as Washer

Steel as structure support

Polythene as bag

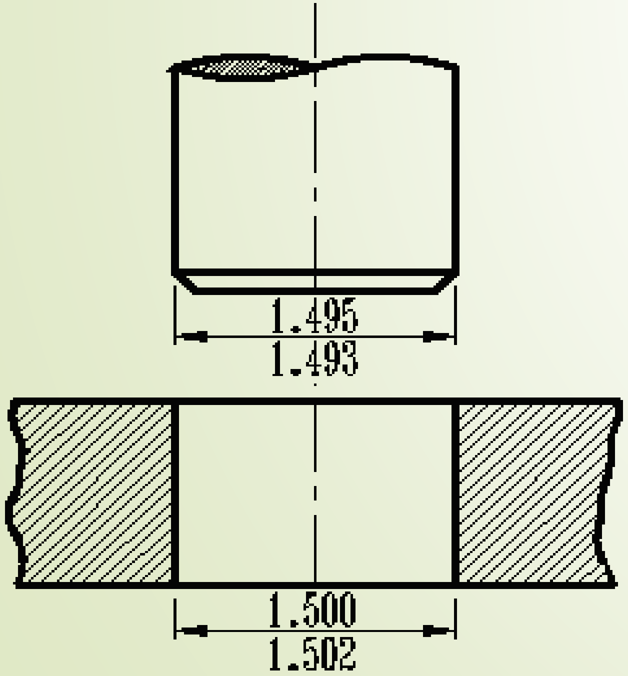
Thermocol for packing

Leather as Belt

Titanium alloy for Medical Implants

Tolerance

- A tolerance is the permissible variation from the specified dimension
- The designer must decide how much variation is allowable from the basic dimension of the component to accomplish the desired function.
- The tolerance on a part is the difference between the upper and lower allowable limits of a basic size dimension



Each manufacturing process has an inherent ability to maintain a certain range of tolerances, and to produce a certain surface roughness (finish).To achieve tolerances outside of the normal range requires special processing that typically results in an **exponential increase in the manufacturing cost**.

Types of Tolerance

Bilateral tolerance

The variation occurs in both directions from the basic dimension. That is, the upper limit exceeds the basic value and the lower limit falls below it.

2.500 ± 0.005 (This is the most common way of specifying tolerances)

Unilateral tolerance:

The basic dimension is taken as one of the limits, and variation is in only one direction

$$2.500^{+0.000}_{-0.010}$$

Standards & Codes in Design

Code is a collection of laws and rules that assists a government agency in meeting its obligation to protect the general welfare by preventing damage to property or injury or loss of life to persons.

S**tandard** is a generally agreed-upon set of procedures, criteria, dimensions, materials, or parts. Engineering standards may describe the dimensions and sizes of small parts like screws and bearings, the minimum properties of materials, or an agreed-upon procedure to measure a property like fracture toughness.

Some Background:

- The U.S. federal government is the largest single creator and user of standards: more than 45,000 (by current estimates)!
- About 210 organization are designated Standard Development Organizations (SDO's)
- Most Standards (about 90%) come from about 20 of these SDO's
- ASTM, ASME, IEEE, AISI (ASM), ASCE, MilStd (Mil Specs), are some of the most important SDO's

Taking them Global!

- ANSI and (U.S. National Committee (USNC)) are the U.S. clearing house for Standards and a founding member of ISO!
- Internationally we see Standard Organization in each of the major Industrial Nations and several Umbrella Groups:
  - International Organization for Standardization (ISO)
  - International Electro-technical Commission (IEC)
  - International Telecommunication Union (ITU)

Why Standards & Codes ?

- it makes the best practice available to everyone, thereby ensuring efficiency and safety.
- it promotes interchangeability and compatibility. With respect to the second point, anyone who has traveled widely in other countries will understand the compatibility problems with connecting plugs and electrical voltage and frequency when trying to use small appliances

How they're used:

- Standards are a "COMMUNICATION" tool that allows all users to speak the same language when reacting to products or processes
- They provide a "Legal," or at least enforceable, means to evaluate acceptability and sale-ability of products and/or services
- They can be taught and applied globally!
- They, ultimately, are designed to protect the public from questionable designs, products and practices
- They teach us, as engineers, how we can best meet environmental, health, safety and societal responsibilities

मानकः पथप्रदर्शकः
Bureau of Indian Standards

Organization	Initials	Country
Bureau of Indian Standards	BIS	India
Badan Standardisasi Nasional	BSN	Indonesia
Brazilian National Standards Organization	ABNT	Brazil
Spanish Association for Standarization and Certification	AENOR	Spain
French association for Standardization	AFNOR	France
American National Standards Institute	ANSI	U.S.
British Standards Institution	BSI	U.K.
Dirección General de Normas	DGN	Mexico
Deutsches Institut für Normung	DIN	Germany
Instituto Argentino de Normalización y Certificación	IRAM	Argentina
Bureau of Standards of Jamaica	BSJ	Jamaica
Euro-Asian Council for Standardization, Metrology and Certification	GOST	Russia (Soviet Union)
Colombian Institute of Technical Standards and Certification	ICONTEC	Colombia
Luxembourg Institute for Standardization, Accreditation, Security, and Quality of Products and Services	ILNAS	Luxembourg
Japanese Industrial Standards Committee	JISC	Japan
Korean Agency for Technology and Standards	KATS	Korea (Republic)
Nederlandse Norm	NEN	Netherlands
South African Bureau of Standards	SABS	South Africa
Standardization Administration of China	SAC	China
Standards Council of Canada	SCC	Canada
Swedish Standards Institute	SIS	Sweden
Finnish Standards Association	SFS	Finland

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Thank You!