Standardisation in the field of ferro alloys

P. Dakshinamurthy*

ABSTRACT

Indian Standards Institution has set up a separate Sectional Committee known as Ferro Alloys Sectional Committee, SMDC 8 in late fifties due to the important role played by the Ferro Alloys in the field of steel industry and in the economy of the country. Standardisation work done by this committee so far, is outlined and some of the important standards on ferro alloys are discussed. The work done by the Methods of Sampling Sectional Committee, SMDC 4 on sampling of ferro alloys and by the Methods of Chemical Analysis Sectional Committee, SMDC 2 on Chemical Analysis of Ferro Alloys is also discussed. Standards prepared by the Technical Committee TC 132 of International Organisation for Standardisation (ISO) on Ferro Alloys are also outlined in this paper.

The term 'ferro-alloy' covers a wide range of base metals alloyed with iron and containing various percentages of other minor elements such as carbon, silicon, phosphorus and sulphur. It may be defined "an alloy of iron with one or more of special elements, at least one of which is usually present in quantity greater than the base iron, so that the ferro alloy can serve as a carrier or vehicle for introducing the requisite elements into special steels, nonferrous alloys, etc." Addition of any constituent to steel in un-alloyed or pure form is sometimes practised perhaps only in special situations. For all practical purposes the additions are invariably made in the form of ferro alloys because ferro alloys are relatively cheap, simpler to produce, easier to add and their specific gravities and melting points are akin to those of steel. Ferro alloys are also added to steel as degassifiers and deoxidisers.

One of the ways of classifying ferro alloys is based on the extent of their usage. Under this classification ferro alloys can be classified in two broad categories - tonnage alloys and speciality alloys. The examples of tonnage alloys are ferro alloys of mangenese, silicon, chromium etc and of the speciality alloys are ferro alloys of refractory and rare earth metals. The speciality alloys like ferro niobium and ferro vanadium have been used in recent years for the production of high strength low alloy steels.

Realising the importance of the part played by the ferro alloys in the economy of the country Indian Stanards Institution (ISI) set up a separate sectional committee known as Ferro Alloys Sectional Committee, SMDC 8 in late fifties to deal with the formulation of standards on ferro alloys. Simultaneously the work relating to the sampling of ferro alloys was dealt by the Methods of Sampling Sectional Committee, SMDC 4 while the chemical analysis of ferro-alloys was dealt by the Methods of Chemical Analysis Sectional Committee, SMDC 2. This article is prepared with a view to highlight the work done by the above Sectional Committees on ferro alloys. The work done by International Organization for Standardization on the standardization of ferro alloys is also reviewed.

* Sr. Dy. Director (Metals), Indian Standards Institution, New Delhi.

Standards on ferro alloys

The ferro Alloys Sectional Committee SMDC 8 of ISI was set up in late fifties under the Structural and Metals Division Council of ISI to deal with the formulation of standards on ferro alloys. The committee consists of experts drawn from Industries, Research Institutions, major consumer organizations and technologists. The first specifications published by this technical committee relate to ferro manganese and ferro silicon. Since the publication of these stardards considerable work was done by the committee resulting in the formulation of a number of Indian Standards on Ferro Alloys (See Annexure I). It may be observed from the annexure that standards have been laid down for some ferro alloys that are not produced at present as well as for others that cannot be produced at all in the country because of the non-availability or very meagre availability of ore resources. The technical committee felt that the former should lead to the development of a particular ferro alloy industry while the latter should serve as purchase specifications in the procurement of ferro alloys from other countries. The committee has also been constantly reviewing published standards to make improvements/amendments to the standards to make them upto date and also to bring out new standards in the field.

Ferro Alloys with Manganese

Manganese alloys are those in which predominent constituent is manganese. Most important from these is ferro manganese - an alloy of iron and manganese containing about 80 percent of manganese. Ferro manganese is widely used in the manufacture of structural steels and also of special steels with a high manganese content. Metallic manganese is used in the manufacture of special steels low in iron, low carbon alloyed steels with a high manganese content, as well as in non ferrous metallurgy.

Ferro manganese and silico manganese are also widely used as reducers in the manufacture of steel. Ferro manganese is employed for desulphurization of steel, while silico manganese is used as a semi product in the manufacture of medium and low carbon ferro manganese and metallic manganese. Following Indian standards have been published in this field :

i) IS : 1111-1964 Spiegeleisen *(revised)*

ii) IS : 1171-1973 Ferromanganese *(second revision)*

iii) IS : 1470-1979 Silicomanganese *(second revision)*

iv) IS : 2021-1973 Metallic manganese *(first revision)*

v) IS : 3012-1965 Chrome manganese

IS : 1171 covers 14 grades of ferro manganese including high carbon ferro manganese, medium carbon ferro manganese and low carbon ferro manganese used in iron and steel industry.

The carbon content specified is 6 to 8 percent for all high carbon grades, 1 to 3 percent for all medium carbon grades and it varies from 0.07 Max to 0.75 Max for different low carbon ferro manganese grades. The manganese content varies from 70 to 82% for high carbon grades, 74 to 78% for medium carbon grades and 80 to 85% for low carbon grades. Limits for other elements like silicon, sulphur and phosphorus have also been specified.

IS : 1470-1979 covers six grades of silico manganese commonly used in the iron and steel industry. The detailed composition of the various grades is given in Table - 1. The particle size ranges and tolerances have also been specified in this standard.

Ferro Alloys with Silicon

Silicon is a strong de-oxidiser, this property determines basically its use in metallurgy. It is used as a de-oxidiser in production of various kinds of steel and sometimes as an alloying element also.

TABLE — 1

Chemical composition of silico manganese

Grade	Percentage						
	Mn	Si	C Max	P Max	S Max	As Max	Ni,Cr,Mo Max
Si 18 Mn 72	70 to 74	16 to 20	1.5	0.20	0.03	0.1	
Si 23 Mn 68	65 to 70	20 to 25	1.5	0.30	0.05	0.1	
Si 18 Mn 68	65 to 70	16 to 20	2.0	0.30	0.02	0.1	
Si 19 Mn 63	60 to 65	17 to 20	2.0	0.30	0.03	0.1	0.75
Si 16 Mn 63	60 to 65	14 to 17	2.5	0.30	0.03	0.1	
Si 26 Mn 53	50 to 55	24 to 28	1.0	0.30	0.03	0.1	

High percentage ferro-silicon in the form of powder is used as a slag-deoxidiser; large amounts of ferro silicon are used for the reduction of various oxides in ferro alloy production; for example, in the production of ferro-molybdenum, ferro vanadium etc.

In this field the following Indian standards have been published

i) IS : 1110-1981 Ferrosilicon *(third revision)*

ii) IS : 2022-1972 Calcium silicon *(first revision)*

iii) IS : 2301-1963 Metallic silicon.

IS : 1110-1981 covers 9 grades of ferro-silicon covering silicon as low as 15-25 percent to as high as 80 to 85 percent. For the various grades the requirements of carbon, sulphur and phosphorus have also been specified. The detailed composition of various grades is given in Table - 2.

IS : 2022 covers two grades of calcium silicon with composition as given in Table - 3.

The alloy may be furnished in lumps or in suitable crushed sizes as agreed to between the purchaser and the manufacturer.

IS : 2301 covers requirements for four grades of metallic silicon. Metallic silicon is mostly used in the non-ferrous metal industry, particularly in the manufacture of aluminium and copper alloys. Addition of silicon improves the physical properties of these alloys. It is also

TABLE — 2

Chemical composition of ferrosilicon

Grade	Constituent, Percent				
	Silicon	Carbon Max	Sulphur Max	Phosphorus Max	Aluminium Max
FeSi 83	80 to 85	0.15	0.050	0.050	1.75
FeSi 78	75 to 80	0.15	0.050	0.050	1.50
FeSi 73 AL 05	70 to 75	0.15	0.050	0.050	0.5
FeSi 73 AL 15	70 to 75	0.15	0.050	0.050	1.5
FeSi 73 AL 25	70 to 75	0.15	0.050	0.050	2.5
FeSi 65	60 to 70	0.15	0.050	0.050	1.0
FeSi 55	50 to 60	0.15	0.050	0.050	1.0
FeSi 48	45 to 50	0.15	0.050	0.050	1.0
FeSi 20 P 15	15 to 25	1.50	0.050	0.15	1.0

TABLE — 3

Chemical composition

Grade	Composition, Percent		
	Ca	Si	C, Max
Ca 30 Si	30 to 35	55 to 65	1.0
Ca 25 Si	25 to 30	55 to 65	1.0

used in the manufacture of organo-silicon compounds. Low calcium silicon metal is used in the production of high aluminium silicon alloys requiring a low calcium value. Low aluminium silicon metal is used in the manufacture of copper base silicon alloys where a minimum aluminium content is required. The details of the chemical composition of metallic silicon as covered in the Indian standard is given in Table - 4.

Ferro Alloys with Chromium

Ferro chrome is an alloy of chromium and iron with addition of carbon, silicon and several other elements. As an alloying element chromium is a component of numerous grades of steel and special alloys. Steels alloyed with chromium increases the steel hardness, strength, yield point etc. Indian Standards Institution has published the following Indian standards covering the details of the various alloys with chromium :

i) IS : 1170-1967 Ferro chromium *(first revision)*

ii) IS : 2023-1973 Metallic chromium *(first revision)*

iii) IS : 2024-1979 Silico-chromium *(second revision)*

IS : 1170 covers various grades of ferro chromium, namely, high carbon ferro chromium, medium carbon ferro chromium, low carbon ferro chromium, high nitrogen low carbon ferro chromium and carbon free ferro chromium. The carbon content varies from 4 to 8 percent for high carbon grades and 1 to 4 for medium carbon grades. It is specified as 0.025 max for some grades and varies from 0.025 to 1.0 percent for other low carbon grades. The chromium content varies from 55 to 70 percent for high carbon grades. It is specified as 60 percent Max for some grades and varies from 60 to 75 percent for other medium and low carbon grades. High nitrogen low carbon ferrochromium grade contains 60-67 percent chromium, 0.10 Max carbon and the percentage of nitrogen varies from 0.5 to 4.0. The carbon free ferrochromium grade has 65 to 75 Cr and traces of carbon. In addition to above limits for other elements like Si, S, P have also been specified. The detailed composition of these alloys are specified in the Indian standard to enable the consumer to select proper quality of ferro chrome.

TABLE — 4

Chemical composition of metallic silicon

Grade	Percentage						
	Si Min	Fe Max	C Max	Ca Max	Al Max	S Max	P Max
Standard Silicon Metal MSi 96	96	2.0	0.10	—	—	0.05	0.05
Low Calcium Silicon Metal MSi 97	97	1.0	0.10	0.10	—	0.05	0.05
Low Aluminium Silicon Metal MSi 98	98	1.0	0.10	—	0.10	0.05	0.05
Purified Silicon Metal MSi 99	99.7	0.015	—	—	—	0.05	0.05

TABLE — 5

Chemical composition of metallic chromium

Grade Designation	Percent						
	Cr Min	C Max	Fe Max	Si Max	Al Max	S Max	P Max
MCr 97C05	97.0	0.06	1.0	0.5	0.08	0.05	0.05
ECr 99	99.6	0.05	0.2	0.2	0.1	0.05	0.02

TABLE — 6

Chemical composition of silico-chromium

Grade	Percent						
	Cr	Si	C Max	Mn Max	Al Max	S Max	P Max
Low Carbon							
i) Si 40 Cr 36	34 to 38	38 to 42	0.06	1.5	1.0	0.03	0.05
ii) Si 44 Cr 36	34 to 38	42 to 46	0.05	1.5	1.0	0.03	0.05
Medium Carbon							
i) Si 24 Cr 46 C100	44 to 48	22 to 26	1.00	1.5	1.0	0.03	0.05

IS : 2023 covers two grades of metallic chromium with the composition given in Table-5.

IS : 2024 covers three grades of silico chromium. The detailed composition of these grades is given in Table - 6.

In this Indian standard the sizes of the silico chromium have also been specified.

Ferro Alloys with Nickel

Ferro nickel is an alloy of nickel and iron with addition of carbon, silicon and several other elements. As alloying element nickel is used in various types of steel. The following Indian standards have been published covering details of alloys with nickel :

i) IS : 2391-1970 Specification for Foundry Nickel *(first revision)*

ii) IS : 2782-1964 Specification for Primary Nickel

iii) IS : 4409-1973 Specification for Ferronickel *(first revision)*

IS : 2391 covers the requirements for foundry nickel used in the iron and steel industry. Foundry nickel is generally used in ferrous foundries in the form of shot for convenience of addition to molten iron at the furnace spout or in the ladle. It contains silicon, iron and carbon which lower its melting point considerably below that of nickel and thus held in rapid solution even at a lower temperature of molten iron. Foundry nickel is also available in the form of ingots weighing 2 to 3 kg. each.

The chemical composition of the foundry nickel as covered in IS : 2391 is given below :

Constitutent	Percent
Nickel (including cobalt)	90.0 to 92.0
Silicon	4.5 to 6.0
Iron, Max	3.0
Ni (including cobalt) + Si + Fe	99 0 Min
Sulphur, Max	0.10
Cobalt, Max	0.50

IS : 2782 covers two grades of primary nickel that is nickel made from ore or matte or

similar raw materials by refining processes, and not produced from remelted metal. These grades of nickel are used for the manufacture of nickel anodes and ferrous and non ferrous alloys. Chemical composition for the two grades of primary nickel as covered in this standard is given in Table - 7.

TABLE — 7

Chemical composition of primary nickel

	Grade-1 %	Grade-2 %
Nickel (including cobalt), Min	99.90	99.50
Sulphur, Max	0.005	0.02
Carbon, Max	0.03	0.10
Iron, Max	0.03	0.20
Copper, Max	0.03	0.05
Antimony, Max	0.001	0.005
Bismuth, Max	0.001	0.005
Lead, Max	0.003	0.005
Total other impurities, Max		

Note : While it is permissible to include cobalt, the percentage nickel shall be not less than 99.60 in Grade 1 metal and 99.00 in Grade 2 metal.

IS : 4409 covers seven grades of ferro nickel under the three broad headings as high carbon, medium carbon and low carbon. The detailed composition of the various grades as specified in the Indian standard is given in Table - 8.

Ferro alloys with vanadium

Vanadium is one of the elements which possesses excellent de-oxidising properties. It is also used in the production of special steels. Because of its ability to increase the strength and improve the plastic properties of steel, as well as to raise the latter's resistance to attrition and impacts, vanadium is widely used in production of various structural, tool and spring steels.

As a rule vanadium is introduced in combination with chromium, nickel, molybdenum, tungsten and other elements.

Compounds of vanadium are widely used in various fields of national economy, chemical industry, agriculture, medicines lacquers and paints etc.

Indian Standards Institution has published the following Indian Standards in this field :

IS : 1466-1972 Ferro vanadium *(second revision)*

IS : 5633-1973 Vanadium pentoxide *(first revision)*

TABLE — 8

Chemical composition of ferronickel

Grade Designation	Ni+Co Min	C	Percent Si Max	Mn Max	P Max	S Max	Cr Max	Cu Max
High Carbon								
3 FeNi 23	18	3.00 Min	2.00	0.50	0.30	0.05	2.0	0.10
2 FeNi 26	21	1.80 Max	4.00	—	0.03	0.04	1.8	0.01
2 FeNi 26S	21	1.80 Max	4.00	—	0.03	0.30	1.8	0.01
Medium Carbon								
02 FeNi 23	18	0.25 Max	0.50	0.50	0.03	0.03	0.10	0.10
02 FeNi 28	28	0.25 Max	0.50	0.50	0.03	0.03	0.20	0.10
Low Carbon								
004 FeNi 26	21	0.04 Max	0.04	—	0.03	0.04	0.03	0.01
004 FeNi 28	28	0.02 Max	0.30	0.50	0.02	0.03	0.10	0.10

Note : Cobalt content shall be not more than 0.05 percent of nickel content.

IS : 1466 covers six grades of ferro vanadium classified in two broad headings of low carbon and foundry grade. The vanadium content in various grades ranges from 35 percent minimum to 75 percent minimum. Limits for various elements like silicon, carbon, sulphur, phosphorus, and aluminium have also been specified.

IS : 5633 covers requirements of one grade of vanadium pentoxide. The requirements for vanadium pentoxide has been specified as 98 percent minimum in this Indian standard.

Miscellaneous

Apart from the above several Indian standards on the various other types of ferro alloys have been published and they are listed at Annexure I (f).

Sampling of ferro alloys

While preparing Indian standard specifications for ferro alloys, it is considered essential that standard procedures for sampling should also be drawn up. This subject was discussed in great detail by the methods of sampling Sectional Committee, SMDC 4 of ISI. Assessing the quality of a consignment of ferro alloys for determining its acceptability or otherwise is a major problem with the consumers. Collecting a representative sample from a consignment of ferro alloys present problems mainly due to the following.

a) Different ferro alloys are demanded and supplied in greatly varying quantities. Some of these are supplied in wagon loads and stored in stock-piles whereas some others are supplied in carefully designed small containers. The procedure for sampling ferro alloys from wagons, stock-piles and from containers cannot be the same.

b) Ferro alloys are supplied in pieces of sizes varying from 25 mm to 150 mm. This requires that a truely representative sample should consist of pieces of different sizes in the same proportion by weight as they occur in the consignment, in order to eliminate errors due to seggregation and other types of bias.

c) The cost of different ferro alloys differs to a very great extent, because of which the procedure for the sampling of costlier alloys should lead to more accurate results and should call for smaller samples.

All these aspects were taken into consideration for the preparation of standard for sampling of ferro alloys IS:1472-1977. For the purpose of procedure laid down in IS:1472-1977, ferro alloys have been grouped into six groups as follows depending upon their nature and the extent of supply and demand :

Group-I	Ferro silicon except FeSi20P15 Grade Silico chromium and Calcium silicon.
Group-II	Spiegeleisen and ferrosilicon FeSi20 P15 Grade.
Group-III	Ferromanganese, Silico manganese, Ferro chromium (high carbon) and Ferro Phosphorus.
Group-IV	Ferro chromium (low carbon)
Group-V	Ferrovanadium, ferrotungsten, ferrotitanium, ferromolybdenum, ferrozirconium. ferroboron, ferroniobium and ferro nickel.
Group-VI	Metallic manganese, metallic silicon, metallic chromium, foundry nickel and misch metal.

The standard specifies the same procedure for all the above groups for obtaining a laboratory sample from the molten metal when the ferro alloy is being manufactured while the procedure for obtaining a sample from a consignment varies for each group depending on whether the material is in lumps or crushed form. From the molten metal three samples are cast at the beginning, middle and at the end of the tapping period. The three cast samples are crushed to 5 mm size and mixed thoroughly to constitute a gross sample weighing 1.5 kg from which a

laboratory sample is prepared by one of the methods specified in the standard.

For sampling of ferro alloys supplied in lumps or crushed form, the consignment is to be divided into a number of equal heterogeneous lots as given in the standard for each group. Procedure for dividing a lot into a number of sublots of equal mass and procedure for obtaining a gross sample consisting of a number of increments/unit samples from each sub lot has been laid down in the standard for each group. A procedure to prepare a laboratory sample from each gross sample has also been laid down for each group. For each ferro alloy the standard also specifies the important elements that are to be analysed from all the laboratory samples individually and the other elements that can be analysed from a composite sample prepared by mixing equal or proportionate quantities of ferro alloy from each of the laboratory samples.

Chemical analysis of ferro alloys

Simultaneously with the preparation of material specifications and sampling methods for ferro alloys, need was also felt for the formulation of standard methods of chemical analysis of ferro alloys, as otherwise the methods employed by various laboratories in India may not always give concordant results. The work of formulation of standards on chemical analysis of ferro alloys was carried out by the methods of chemical analysis sectional Committee SMDC 2 on which scientists and experts in the field of metullurgical analysis are represented. The first standard finalised by this technical committee was IS : 1559-1961 Methods of chemical analysis of ferro alloys which prescribes the methods for the determination of the various constituents of nine ferro alloys in different sections (see Annexure II).

While preparing this standard care has been taken to see that the methods prescribed are such that they can be used as referee methods in case of dispute. In some cases alternate methods have also been included. Since the publication of IS:1559-1961 considerable work was done by the committee resulting in the formulation of number of standards on the chemical analysis of other ferro alloys and the standards so far published are given in Annexure II. It may also be seen from the annexure that a number of standards are yet to be prepared by the committee on the chemical analysis of other ferro alloys like ferroniobium, ferrozirconium, ferronickel, metallic chromium, chrome manganese etc.

While reviewing IS : 1559-1961 recently, the technical committee decided that this standard should cover only methods of analysis of ferrosilicon and methods of analysis of other ferro alloys should be covered in separate standards. It was also decided that this standard should cover the methods of chemical analysis of ferrosilicon for different elements in different parts. This decision resulted in the publication of IS:1559 (Part I to VII)-1982 (see Annexure II) superseding section I of IS:1559-1961. Section II to Section IX of IS:1559-1961 continue to hold good till separate standards are published for other ferro alloys in due course.

Standardization at international level

Recognizing the important role of standards in the promotion of international trade and commerce, the International Organization for Standardization (ISO) was set up in 1947 to "facilitate the international Co-ordination and unification of technical standards". ISO at present comprises of the national standard bodies of 72 countries. The object of ISO is to promote the development of standards in the world with a view to facilitate international exchange of goods and services and to develop mutual cooperation in the sphere of intellectual, scientific technological and economic activity. The results of ISO work are published as International standards.

The work relating to the standardization of ferro alloys at International level is dealt by the technical committee TC 132 'Ferro Alloys'. At

present there are three subcommittees under TC 132 to deal with the formulation of standards on the sampling, chemical analysis and specifications of ferro alloys. So far TC 132 has published 17 standards on chemical analysis and material specifications of ferro alloys (see Annexure-III), India, as a participating member of TC 132 takes active interest in its work to ensure that our national interest and views receive due consideration before an international standard on any subject is finalized.

Implementation of Indian standards

From the review given above it is clear that a number of standards have been prepared on material specifications, sampling and chemical analysis of ferro alloys by ISI and many more are required to be covered to meet the varied requirements of the industry. The process of standardization is incomplete if standards are not used by the industry. Indian standards are not mandatory but the process guiding their preparation is such that they should automatically become acceptable for use by the industry and trade. In the process of using the standards, any difficulty experienced could be noted and fed to the sectional committee for necessary revision or amendment of the standard.

One of the methods of implementation of standards is the adoption of ISI Certification Marks Scheme under which manufacturers are licenced to use ISI Mark on goods produced by them in conformity with relevant Indian Standard. The basic purpose of this scheme is not only to ensure conformity of the end product to the requirements laid down but also to stream line production process from the raw materials to the finished stage. ISI Mark gives third party guarantee about the quality of the material. The list giving the details of licences which have been granted under ISI Certification Mark so far in the field of ferro alloys, can be obtained from ISI.

Finally it would be appropriate to add that ferro alloy industry on its own has been alive to the need for standardization and has displayed active co-operation in the work. ISI looks forward to still greater co-operation from the industry with a hope to continue to serve the industry to its satisfaction.

ANNEXURE—I

Indian Standard Specifications prepared by the Ferro Alloys Sectional Committee, SMDC 8

a) Chromium

IS : 1170-1967 Ferro chromium *(first revision)* (With amendment No. 1 and 2)
IS : 2023-1973 Metallic chromium *(first revision)*
IS : 2024-1979 Silico chromium *(second revision)*

b) Manganese

IS : 1111-1964 Spiegeleisen *(revised)*
IS : 1171-1973 Ferro manganese *(second revision)*
IS : 1470-1979 Silico manganese *(second revision)*
IS : 2021-1973 Metallic manganese *(first revision)*
IS : 3012-1965 Chrome manganese

c) Nickel

IS : 2391-1970 Foundry nickel *(first revision)*
IS : 2782 1964 Primary nickel (with amendment No. 1)
IS : 4409-1973 Ferro nickel *(first revision)*

d) Silicon

IS : 1110-1981 Ferro silicon *(third revision)*
IS : 2022-1972 Calcium silicon *(first revision)*
IS : 2301-1963 Metallic silicon

e) Vanadium

IS : 1466-1972 Ferro vanadium *(second revision)*
IS : 5633-1973 Vanadium pentoxide *(first revision)*

f) Miscellaneous

IS : 1467-1972 Ferro tungsten *(second revision)*
IS : 1468-1981 Ferro titanium *(first revision)* (With amendment No. 1)
IS : 1469-1970 Ferro molybdenum *(second revision)*
IS : 1471-1972 Ferro phosphorus *(first revision)*
IS : 3011-1973 Ferro zirconium *(first revision)*
IS : 3013-1980 Ferro boron *(first revision)*
IS : 3014-1973 Ferro niobium (ferro columbium) *(first revision)*
IS : 4182-1966 Misch metal
IS : 5632-1970 Wolframite concentrate
IS : 5634-1970 Molybdenum oxide (technical)
IS : 7148-1980 Ferro alloys for welding industry
IS : 7965-1976 Niobium (columbium)
IS : 7970-1976 Tantalum powder, capacitor grade

ANNEXURE—II

Indian Standard Specifications for Methods of Chemical Analysis of Ferro Alloys

IS : 1559-1961 Methods of chemical analysis of ferro alloys covering :

i) Ferrosilicon
ii) Ferromanganese and Spiegelisen
iii) Ferrochromium
iv) Ferrovanadium
v) Ferrotitanium
vi) Silicomanganese
vii) Ferrotungsten
viii) Ferromolybdenum
ix) Ferrophosphorus

IS : 1559-1982 Methods of chemical analysis of ferrosilicon

IS 1559 (Part I) - 1982 Determination of silicon *(first revision)*

IS : 1559 (Part II) - 1982 Determination of carbon *(first revision)*

IS : 1559 (Part III) - 1982 Determination of sulphur *(first revision)*

IS : 1559 Part IV) - 1982 Determination of phosphorus *(first revision)*

IS : 1559 Fart V) - 1982 Determination of aluminium *(first revision)*

IS : 1559 Part VI) - 1982 Determination of calcium *(first revision)*

IS : 1559 (Part VII) - 1982 Determination of manganese *(first revision)*

IS : 2017 - 1967 Methods of chemical analysis of metallic manganese

IS : 2018 - 1964 Methods of chemical analysis of calcium silicon

IS : 2020 (Part I) - 1968 Methods of chemical analysis of silico-Chromium Part-I Analysis of silicon and chromium

IS : 2277-1964 Methods of chemical analysis of metallic silicon

IS : 2390-1967 Methods of chemical analysis of foundry nickel

IS : 2766 (Part I) - 1968 Methods of chemical analysis of primary nickel Part-I

IS : 3295 (Part I) - 1969 Methods of chemical analysis of ferro-boron Part-I Analysis for carbon, silicon and aluminium

IS : 3295 (Part II) - 1970 Determination of boron in ferro boron (with amendment No. 1)

IS : 5425 (Part I) - 1969 Methods of chemical analysis of misch metal (Part-I Determination of cerium)

ANNEXURE—III

Standards Prepared by the Technical Committee TC 132 of International Organization for Standardization on Ferro Alloys

TC 132 Ferroalloys

ISO 4139—1979	Ferrosilicon - Determination of Aluminium Content - Flame atomic Absorption Spectrometric Method
ISO 4140—1979	Ferrochromium and ferrosilicochromium - Determination of chromium content - Potentiometric method
ISO 4158—1978	Ferrosilicon ferrosilicomanganese and ferrosilicochromium - Determination of silicon content - Gravimetric method
ISO 4159—1978	Ferromanganese and ferrosilicomanganese - Determination of manganese content - Potentiometric method
ISO 4173—1980	Ferromolybdenum - Determination of molybdenum content - Gravimetric method
ISO 5445—1980	Ferrosilicon - Specification and conditions of delivery
ISO 5446—1980	Ferromanganese - Specification and condltions of delivery
ISO 5447—1980	Ferrosilicomanganese - Specification and conditions of delivery
ISO 5448—1980	Ferrochromium - Specification and condition of delivery
ISO 5449—1980	Ferrosilicochromium - Specification and conditions of delivery
ISO 5450—1980	Ferrotungsten - Specification and conditions of delivery
ISO 5451—1980	Ferrovanadium - Specification and conditions of delivery
ISO 5452—1980	Ferromolybdenum - Specification and conditions of delivery
ISO 5453—1980	Ferroniobium - Specification and conditions of delivery
ISO 5454—1980	Ferrotitanium - Specification and conditions of delivery
ISO 6467—1980	Ferrovanadium - Determination of vanadium content - Potentiometric method
ISO/TR 7655—1980	Ferroniobium - Determination of niobium content - Gravimetric method