6.1. General Remarks

The end of the major construction period of the project is followed by the test runs and commissioning of the equipment. This is first carried out with individual equipment item and then in equipment groups.

The hot commissioning activities under operating load with material are the final stage in a long chain of events starting from the conceptual idea for the project, contract negotiations, engineering, plant erection and production. They mark the hour of truth for the plant designer, the erector and the owner.

All parties are very much interested in a quick, smooth and save start-up because delays in the plant start-up can increase considerably the capital requirement. The costs arising during the start-up period of a new direct reduction plant can be minimized with proper preparation.

Defects and unforeseen events occur during each start-up period. A trouble-free start-up of a DR-plant would be desirable but it should be considered as difficult even if adequate care is taken during design, procurement and erection stage. This can become even more difficult if compromises have had to be accepted in the quality of the equipment and/or if the installation of plant has had to be carried out under extreme time pressure, etc.

The start-up of the completely erected plant will only proceed smoothly and successfully if:

- the plant was carefully designed, erected and inspected,
- the quality of raw materials and utilities do not substantially differ from the specifications mentioned under the heading "Basis of Design",
- spare parts as recommended by the suppliers are available in the plant's store,

- the operating personnel is qualified, has undergone thorough training and is prepared for their functions,
- the start-up is carefully planned and carried out by an experienced crew of start-up engineers,
- the transfer of process, operating and maintenance know-how from the commissioning crew and suppliers specialists to the customer's personnel is seriously followed up and accomplished patiently.

6.1.1. Pre-operational Procedures

Prior to pre-commissioning and commissioning of the Direct Reduction Plant, pre-operational procedures have to be carried out by the commissioning personnel. These procedures and checks cover the phase between handover from construction to pre-operation stage and start-up.

The preparatory steps considered essential to subsequent operations are:

6.1.1.1	Inspection of Equipment
6.1.1.2	Rechecking for Completion
6.1.1.3	Testing and Flushing of Piping and Vessels
6.1.1.4	Check-up of Electrical Equipment and Systems
6.1.1.5	Check-up of Instruments, Loops and Interlocks
6.1.1.6	Commissioning Testing
6.1.1.7	Hot Commissioning
6.1.1.8	Detailed Pre-Operation Instructions

6.1.1.1. Inspecting of Equipment

Qualified inspectors check the quality of materials and the fabrication of all important equipment already in the manufacturer's shop. Field inspection of

1.3 RAW MATERIALS

1.3.1 Iron Ore

Various Indian iron ore samples have been analyzed and/or tested with regard to their suitability for direct reduction in the rotary kiln in Lurgi's laboratories, many of which had been found to be suitable.

No test work was carried out for the project of Bhushan. Therefore, only the analysis of the ore selected by Bhushan for this project is given below:

LUMP ORE ANALYSIS

Iron Ore	
Fe_{tot}	63 – 65 %
$SiO_2 + Al_2O_3$	3.5 – 4.0 %
S	0.02 % max
P	0.04 – 0.07 %
L.O.I.	1.0 – 3.5 %

The size range of the ore as to be used is 5 – 20 mm.

The analysis above indicates 2 weak points of the ore:

- the Phosphorous content of the ore is relatively high and has to be taken care of during steel making.

- Ores with a high LOI normally have a stronger tendency to decrepitate during reduction and could lead to an increased portion of DRI fines. This in turn could influence the general reduction performance of the rotary kiln.

1.3.2 Coal

The properties of the reductant, both from a chemical and physical point of view, are of great importance to the process. As compared to iron ore, its analysis normally varies in much wider ranges and thus can also influence the performance of the plant more severely. Consequently, more frequent analyses have to be carried out in order to allow corrective measures to be taken.

In general, the following main characteristics of the coal are of interest:

- Reactivity, which is a measure for the conversion of CO_2 to CO, according to the Boudouard reaction
- Ash content. The ash content reduces the active kiln volume available for the iron-bearing material and should be as low as possible.
- Caking and swelling indices influence the agglomeration behaviour and should be as low as possible
- Ash fusion point should be at least 100 °C higher than the kiln operating temperature.

Due to the fact that no detailed analysis was done by Lurgi and also no test work was carried out , again, only the analysis indicated by Bhushan is tabled below:

H_2O	6 – 8 %
Ash	25 – 30 %
C-fix	40 – 44 %
VM	29 – 31 %
Sulfur	0.5 – 0.8 %
Caking capacity	n.a.

Swelling index	n.a.
Ash softening temperature	+ 1200/1250 °C
Reactivity	+ 1.5 – 2 cm³CO/g°Csec

It has to be also pointed out that an ash content of < 25 % on a consistent basis is desirable from an operational point of view. High ash levels are increasing the energy consumption and represent a ballast to the operation. Exceeding this ash level goes along with a decrease of the plant's capacity and possibly with increased accretion activities in the rotary kiln.

A typical coal analysis that can be regarded as suitable for the direct reduction process is shown in the following table.

CHEMICAL AND PHYSICAL DATA OF COALS

Proximate analysis		
H_2O	%	10
Ash	%	15 – 20
Volatiles	%	30 – 35
C-fix	%	55
S	%	0.51
Reactivity	cm³CO / g sec	> 2
Swelling index		decays
Caking capacity		< 3
Calorific value		
Net	kJ/kg	28,000
Gross	kJ/kg	28,800
Melting behaviour of coal ash		
Softening point	°C	1250
Melting point	°C	> 1550
Flow point	°C	> 1550