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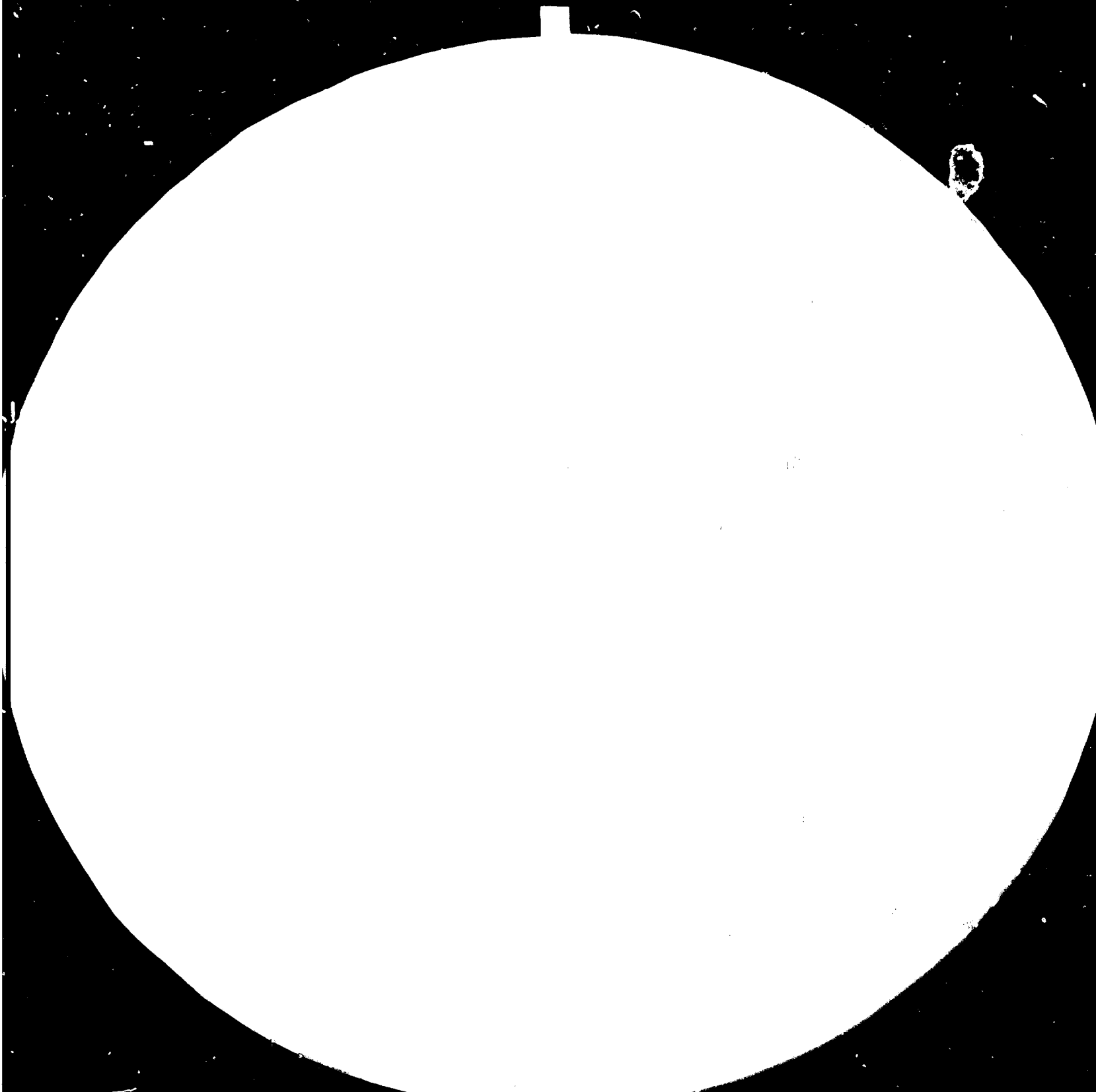

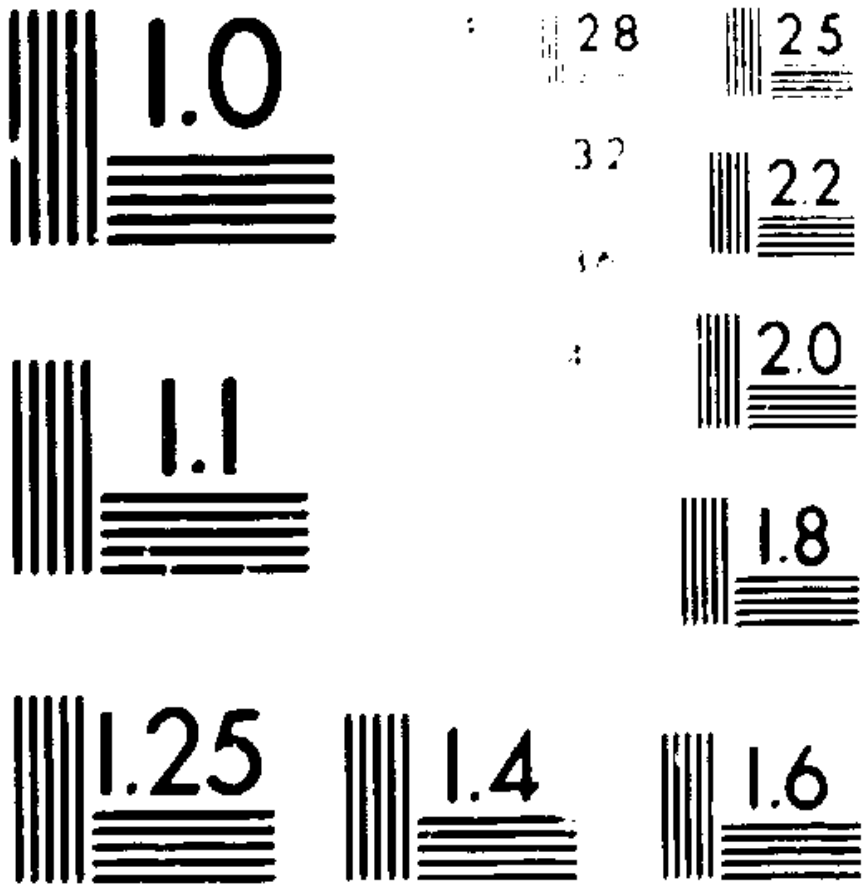

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INTEGRATED HUMAN RESOURCE DEVELOPMENT*

by

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INTEGRATED HUMAN RESOURCE DEVELOPMENT

1.0 INTRODUCTION

The development of industrial and technological manpower has a profound influence on, and can be a vital factor in enhancing the level of industrial development in all developing countries.

An overwhelming proportion of industrial output of developing countries is based on technology imported at exorbitant cost from the developed countries. The economic crisis in most developing countries created largely due to oil price hike had restricted the investments in critical inputs of technology and trained manpower so essentially for growth of core sector. Moreover, industrial technology in developed countries have pronounced labour saving bias and are consequently judged to be inappropriate to the general situation in developing countries where capital is scarce and labour is relatively abundant. Over the period of last two decades each of the developing countries notably Brazil, Mexico, Argentina, Republic of Korea and India in a modest way have acquired specific skills which, if shared, can substantially reduce the extent of dependence. In this paper the author has presented the steps being taken at WRI for training of manpower and knowledge dissemination.

Welding technology is a dominating feature of today's production technology and it is no exaggeration to say that the industrial progress of any country depends on the welding infrastructure available within the country. Very few technology institutes in India

offer an exclusive programme in welding engineering which necessitated the fabrication industry to organise themselvestraining of their welding personnel abroad at exorbitant cost. The School of Welding of our Institute has been set up to bridge this gap and to meet the growing demand of welding personnel. The School has a regular 3-tier programme of training and conducts basic and advanced training programmes in welding and related subjects for Engineers and Supervisors apart from training highly skilled Welders in various processes of welding. The aim of these programmes is to prepare them to take up responsible position in fabrication industries. The training methods and syllabi at various welding Institutes abroad have been assimilated into an interwoven pattern of theory. WRI also assists organizations to set up their own Welding Training Centres.

2.0 PROFILE OF WELDING PERSONNEL AND TRAINING OF INDUSTRIAL MANPOWER

2.1 Welding Engineer:

Innovations in product designs to contain the present day operating conditions of very severe nature, calls for improved materials from the steel manufacturers, making the welding engineer's job tougher, as these materials demand very elaborate and meticulous welding techniques. Modern structural steels offer enough challenges to the welding professionals, requiring them to understand the material properties and welding process capabilities at much more depth. Welding men have to reach for informations on design aspects, on heat treatments, on welding techniques and on inspection requirements. One has to very closely understand the optimum properties of one's weldment,

that is to be generated, keeping economy in mind.

Very few Universities in the world, offer undergraduate curriculum in welding engineering. There are but many institutions which offer post-graduation, and in India, post-graduation in welding or in metal joining is possible at Indian Institutes of Technology(IITs) at Madras, Kharagpur, Delhi and Bombay, Regional Engineering College (REC) at Tiruchirapalli and at the University of Rourkee.

2.1.1 Basic Welding Engineers Course Conducted at WRI:

The Welding Research Institute (WRI - established in 1975) apart from having tie-ups with the regular conduction of the Master of Engineering (M.E) in welding at REC, Tiruchirapalli, assists the M.E. project works of other institutions. WRI has its own organ of training the industrial manpower called the 'School of Welding'. Graduate engineers of Mechanical, Electrical, Structural and Metallurgical backgrounds are admitted at WRI for an eight weeks consolidated course in welding with a rigorous industrial bias (50% hours practicals). A broad syllabus based on which lectures are given is furnished in the Annexure. Seventy lectures are totally taken by our Specialists in each field for Engineers course. Group discussions and industrial tours are also organised. Almost all processes are covered in the practical sessions with appropriate job excercises. More than 250 engineers have already attended the above Welding Engineers courses conducted at WRI.

2.2 Welding Supervisors:

As mentioned earlier in the introduction (1.0), a company or a country has to necessarily go for periodic austere measures, and fall back on self-generated technology, owing to the widening gap between the productivity and the know-how acquirement. The recessive trend in the global level did further aggravate this situation. Notwithstanding, the Production Cores of an industrial infrastructure affected thus, will still be alive with the usual day-to-day innovations. The experienced supervisors usually will not find it difficult to contribute, with a little extra time. Such developmental offshoots are also of very significant nature during the present days. It is, hence, the prime responsibility of any organisation to build up a technically sound supervisory team. Two types of supervisory staff are observed in Indian industries. The welder-turned chargemen and the diploma holders of various branches of engineering. A proper mix of the above two categories constitutes a sound and innovative supervisory core. Nearly 50,000 Diploma holders pass out annually from the different Polytechnics in India. Those who join the engineering fabrication and allied industries get connected with welding. WRI offers a four weeks course in welding to mould these two categories of supervisors into welding technicians. The welding technicians manage the shop floor welding work centres, assist in consumables procurement and distribution, impart training to welders, assist in welding procedure and welder qualifications, assist in conducting various welding technology activities such as weldability establishments, fixture designs and also partake in industrial engineering

studies in welding.

2.2.1 Basic Welding Supervisors Course:

The basic welding supervisors course organised at WRI is of 4 weeks duration. Both the above described categories of supervisors are inducted for this course. The training programme has equal accent on theory and practice. The inputs are arrived at a lower comprehension target audience hence the syllabus (see Annexure) has been designed to include only very essential aspects connected with welding technology. Forty lectures are arranged for basic welding Supervisors course. Total number of supervisors trained in WRI so far is around 200.

2.3 Welders:

Manual welding is one of the many modern industrial skills evolved during the metal fabrication era. Welder of the present day has not inherited his skills secretly, like a traditional blacksmith or goldsmith. Lack of welding technological awareness in a firm bluntly force its employer to look up for the consent and favour of the welders, in order to try out a different electrode or a new manual welding procedure. Technology implementation thus invariably ends up in an unscientific drive, accelerated by target dates. There is but only one way to counteract to the inertia caused due to the discharge of residual, disoriented skills by welders while handling a new welding fabrication. That is, to expose, pick-up and rationalise the manual skills through orientation training and qualification - qualification to the

specific workmanship of a job, as far as possible.

Welders in India are of two fundamental categories -

1) Welders with work experience alone; and
2) Welders who have put in nominal experience after passing out from the 150 odd Industrial Training Institutes (ITIs) of the country (admissions to ITI is after 8 years of general schooling).

2.3.1 Basic Welders Course:

The type of programmes available for welders in WRI are -

i) Organisation-based training; and
ii) Training for qualification as per various Industrial Codes of Practice. Welders are trained from 4 to 12 weeks depending upon their initial skill levels, nature of jobs and the stringency of the relevant codes. The various codes to which qualifications are undertaken in WRI School of Welding are - Indian Boiler Regulations (IBR), ASME Section IX, DIN 8560 and the Indian Standards involving the various inspection agencies like Indian Boiler Inspectorate, Lloyd's Register of Industrial Services, American Bureau of Shipping, Bureau Veritas, etc. The Instructor to Trainee ratio is kept at 1:5 approximately. One welding machine per individual trainee is also provided. Minimum 10% of the total duration will be allocated for theoretical inputs. Skill simulator is also employed. This simulator covers three Manual Metal Arc Welding parameters: Tracking, Arc length and Electrode angles. The welders are given theoretical inputs depending on their specific needs. See Annexure for welders course syllabus.

All subjects from Part B and selected subjects from Part A are taught in nearly 10 lecture sessions. Practical sessions are followed up with weekly tests including radiographic tests if required. The institute is recognised recently as the competent authority to certify welders. Total number of welders trained and obtained qualification at WRI are more than 480.

2.4 The basic courses discussed above are followed up by organising refresher courses from time to time, for the continued benefit of the welding personnel. Short-term courses on welding and inspection topics are regularly conducted at WRI. More than 1000 participants have attended so far these courses.

2.5 Package programmes in welding having two to three days duration are also conducted at the customers' premises, covering all three levels of personnel in welding.

2.6 Inter-action with Educational Institute:

WRI has been assisting several Educational Institutions like Regional Engineering College, Tiruchirapalli, and Government Polytechnic, Tiruchirapalli, and in the conduct of Post-graduate and Post-diploma programme in welding technology. Many Post-graduate students from various Technical Universities in India are encouraged in taking up industrial research projects as part of their thesis work. The Institute has been recognised by Madras University as Centre for Doctoral Research.

With the vast experience gained in the last few years in the field of training, WRI is now fully geared to

extend its assistance for establishing similar Research and Development Centres in other developing countries.

3.0 APPLICATION OF QUALIFIED WELDING MANPOWER(WELDERS)

3.1 Welding Procedure Specifications:

A total quality assurance scheme would have certainly made all attempts to ensure the qualifications of all the resources and the environment, meant for production. Raw materials, manufacturing and inspection procedures, overall facilities and systems, qualified manpower, all these factors are listed and approvals are obtained before work is begun.

Depending on the type of construction, broad Welding Procedure Specifications (WPS) are usually drawn. A list of general welding parameters are given below:

i) Scope of work and code by which the work is covered, etc;
ii) Welding process or processes employed;
iii) Base metals and applicable specifications;
iv) Type, classification and composition of filler rods and weldment;
v) Type of current and current ranges;
vi) Welder qualification requirements;
vii) Joint designs and tolerances;
viii) Joint preparation and cleaning of surfaces for welding;
ix) Tack welding;
x) Joint welding details;
xi) Positions of welding involved at factory and at site;

xii) Preheat, interpass and post-heat temperatures;
xiii) Hot peening;
xiv) Heat input - Electrode run length, carriage speed, etc;
xv) Post-weld heat-treatment;
xvi) Repair of welds;
xvii) Inspection - Quantum and stages - Acceptance levels;
xviii) Records

The purpose of welding procedure specification WPS) and procedure qualification record (PQR) is to determine that the weldment proposed for construction is capable of having the required properties for its intended application. It is pre-supposed that the welder, or the welding machine operator performing the welding procedure qualification is a skilled artisan. The welding procedure qualification is therefore, strictly to establish the properties of the weldment and not the skill of welder or the welding machine operator. In addition to the basic mechanical property requirements, such as engineering tension test and bend test results, a weldment is some times prescribed for severe service conditions as well. There the required degree of the ductile to brittle transition temperature of the weldment have to be low. Procedural tests in those cases include impact tests also, to assess the notch toughness property of the weld.

In performance qualification, the basic attempts are to establish the ability of the welder to deposit sound metal. In case of welding operator qualifications it is his mechanical ability to operate the welding machine that is tested and acknowledged.

Depending on their influence on obtaining a desired weldment, the welding parameters are classified and listed. Some of them are listed as "Essential variables" some of them as "Supplementary Essential Variables" and the rest as "Non-Essential Variables".

Essential Variables when changed beyond allowable limits while welding, alters the prescribed weld properties. Hence, production welds with such altered parameters should not be continued without requalification and certification.

More numbers of variables from the list are declared as essential, in case where a procedure qualification is applied for a weldment going for high notch toughness applications.

Those welding variables which when changed during welding (within logical limits) do not cause to alter the desired weld properties are just entered in the Procedure Qualification Record (PQR). Hence production welds with such altered parameters could be continued without any need for requalification of the welding procedure.

During welders qualification, only the Essential Variables (as applicable to welders' skill) are considered and production welds with such altered

parameters should not be continued without requalifying the welder. A welding machine operator usually gets qualified along with the procedure test. The requalifications are to be suitably enforced as and when certain parameters are declared as essential variables by the inspection agencies.

3.2 Welding Performance Qualifications:

A large number of Industrial Codes now-a-days recognise prequalified welding procedures, as the manufacturing firms are able to produce the documentary evidence for such procedures, as in vogue in their organisations. The selection, training and qualification of welders are the next few steps. Some of the popular codes to look for, at this juncture are:

1) Indian Boiler Regulations - IBR Chapter XIII
2) ASME Boiler and Pressure Vessel Code - Section IX (Welding and Brazing Qualifications)
3) DIN 8560 - (Testing of welders for welding steel)
4) BS 4672 - (Approval Testing of welders when procedural approval is not required)

There are also numbers of other specifications for welder testing, pertaining to individual codes of construction.

A welder's plate test coupon can be maximum 300mm x 400 mm with appropriate thickness to cover the allowed, specified thickness ranges. Similarly 2 pipes (or tubes) having a maximum of 125 mm length each are joined together for a pipe weld test coupon.

The test coupons are then subjected to radiographic testing. Welders are generally failed for the following indications in the radiographic film:

i) severe root porosities/blow holes
ii) cluster porosities
iii) cracks
iv) lack of fusion/lack of penetration

After necessary postweld heat treatment the plates or pipes are marked, stamped, cut and machined into mechanical test specimens. Though the requirements of the codes are slightly varied, 2 Face Bend tests and 2 Root Bend tests alone are conducted for Performance Qualifications over and above the radiographic evaluation. An opening of around 3 mm on the outer bent surface of the weld causes rejection. Premature cracks at the corners of the bend specimen are leniently admitted.

Some of the Essential Variables for the welders performance qualifications are listed below:-

1.0 Deletion of backing in arc welding processes and also change from double side welding to single side welding in Butt welds;

2.0 Addition of backing in Gas welding processes;

3.0 Exceeding the allowable thickness limits which are qualified;

4.0 Violating the allowable diameter limits which are qualified in case of pipe welding;

5.0 Change from one type of electrode coating specified to the other that is more difficult

for the welder (Eg. from Rutile to Basic covering);

6.0 Change from one welding position to a more difficult position;

7.0 Change from vertical-up welding to vertical down welding and also vice versa.

Having prescribed in the first place, the desired weldment, two major agencies are to act upon the joint to produce the weldment. They are -

i) 'Energy Carrier' (Electric Discharge Energy in the form of Arc); and

ii) 'Application Mode' (Manual welding through a welder or a torch manipulation mechanism).

Both the above media are subjected to their own inherent random variations, but within logical limits, an attempt is made to establish the repeatability of the selected joining process, to achieve the calculated weld properties, through procedure and performance qualifications. This can be represented as below:

$P \propto CA$

where P : is the desired weld property constituted of i) Metallurgical compatibility; and ii) Mechanical soundness.

C : is the Energy Carrier Factor, which decides the capability of the selected process, to control chemical composition and heat input factors, contributing together to the metallurgical compatibility of the weld.

A : is the Application Factor, which decides the ability of the welder or any other torch manipulator to deposit mechanically a sound weld metal.

The Energy Carrier effect 'C' is chiefly verified through a procedure test. The Application Factor 'A' on the other hand influences only the incidence of the deposit's mechanical discontinuities, and the same can be revealed in most of the cases through radiography. American Codes and also the current German specification for welders testing (DIN 8560 - May 1982) have accepted this fact and have incorporated this in the code requirements, doing away with the Engineering Bend Tests over and above the radiographic tests. The welder's performance tests coupon of the prescribed weld length has thus to clear only a radiographic evaluation. Mechanical Bend Tests have been suggested at the same time as an alternative to radiographic tests in the American Codes, mostly in the absence of radiographic inspection facility (or vice versa).

4.0 CONCLUSION

1.0 Reliance on self-generated technology is visualised largely through building up adequate strength of welding personnel in all the three levels;

2.0 Welding Engineers should comprehend themselves closely, the optimum properties of the weldment, keeping economy in mind. Practically oriented training of the engineering graduates is the only way by which it is possible;

3.0 A technically sound supervisory team is to be maintained by any organisation in order to assist internal developmental schemes, at all times;

4.0 Orientation training and qualification of welders are to be reckoned in view of implementing the technology to such constructions demanding high workmanship;

5.0 Various welding personnel should be exposed from time to time to courses in contemporary welding process and practices and also on future welding trends;

6.0 Procedure and performance qualifications are to be rightly understood and resorted to while undertaking coded constructions;

7.0 Monitoring of approved welding procedures and scheduling of procedure and welder requalifications are to be enforced as and when warranted;

8.0 The welder's performance test has to be limited only to verify his ability to deposit mechanically sound weld metal and the requirements of metallurgical compatibility are to be attributed to the welding process characteristics.

ANNEXURE

BROAD SYLLABI OF THE PROFESSIONAL COURSES CONDUCTED BY THE WELDING RESEARCH INSTITUTE

1.0 WELDING ENGINEER'S COURSE (CONDUCTED AT WRI) - DURATION : 8 WEEKS

1.1 Arc Physics
1.2 Welding Power Sources
1.3 Flux Coated Arc Welding
1.4 Flux Shielded Arc Welding
1.5 Gas Shielded Arc Welding
1.6 Resistance Welding
1.7 Under-water Welding
1.8 Advanced Welding Processes
1.9 Weld Design and Economy
1.10 Safety
1.11 General Metallurgy
1.12 Welding Metallurgy
1.13 Defects, Testing and Acceptance of Welds

2.0 WELDING SUPERVISOR'S COURSE (CONDUCTED AT WRI) - DURATION : 4 WEEKS

2.1 Processes and Power Sources
2.2 Consumables
2.3 Accessories
2.4 Other Processes
2.5 Weld Design and Economy
2.6 Safety
2.7 Basic Welding Metallurgy
2.8 Weld Defects and Quality Control

3.0 WELDER'S COURSE (CONDUCTED AT WRI) - DURATION : MUTUALLY DECIDED (All Subjects from Part B and any one or a Combination of Subjects From Part A)

3.1 PART-A

3.1.1 Manual Metal Arc Welding
3.1.2 TIG Welding
3.1.3 MIG Welding
3.1.4 Submerged Arc Welding
3.1.5 Oxy-Acetylene Gas Welding and Cutting

3.2 PART-B

3.2.1 Elementary Electricals
3.2.2 Elementary Metallurgy
3.2.3 Weld defects, Detection and Acceptance Criteria
3.2.4 Weld Drawings and Edge Preparations