

DOCUMENT RESUME

ED 039 504

AC 008 119


TITLE Training Guidelines: Glass Furnace Operators.  
INSTITUTION Ceramics, Glass, and Mineral Products Industry  
Training Board, Harrow (England).  
NOTE 28p.  
EDRS PRICE EDRS Price MF-\$0.25 HC-\$1.50  
DESCRIPTORS Employment Qualifications, \*Equipment Utilization,  
\*Glass, \*Guidelines, \*Industrial Training,  
Occupational Information, Skill Development,  
\*Skilled Workers, Task Analysis, Trade and  
Industrial Education  
IDENTIFIERS Great Britain

ABSTRACT

Technological development in the glass industry is constantly directed towards producing high quality glass at low operating costs. Particularly, changes have taken place in melting methods which mean that the modern furnace operator has greater responsibilities than any of his predecessors. The complexity of control systems, melting rates, tank capacities, and other technical factors demand that he be highly qualified. This manual of training guidelines was developed by a group of production managers, furnace engineers, and training specialists from the industry, in the belief that systematic training and development of furnace operators could make a significant contribution toward increased efficiency and productivity. Included as appendixes are a job description for the furnace operator, a job analysis with detailed breakdown of individual items, a personnel specification, and a list of suggested training aids and their sources. (Author/MF)

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# **Ceramics Glass and Mineral Products Industry Training Board**

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## **Training Guidelines**

# **Glass Furnace Operators**

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**TRAINING GUIDELINES**

**GLASS FURNACE (MELTING) OPERATORS**

## INTRODUCTION

Technological development in the glass industry is constantly directed towards producing high quality glass at low operating costs. Particularly, changes have taken place in melting methods which mean that the modern furnace operator has greater responsibilities than any of his predecessors. The complexity of control systems, melting rates, tank capacities and other technical factors demand that he be highly qualified.

The Glass Committee believe that systematic training and development of furnace operators could make a significant contribution towards increased efficiency and productivity.

The committee's working party studying training for craft occupations has therefore appointed a sub group to prepare guidelines for training furnace operators which can be adapted to the varying conditions in individual firms. The problems have been carefully studied by a specially appointed group of production managers, furnace engineers and training specialists from the industry. (See Appendix A).

Training on the lines suggested here can provide furnace operators who are competent in their jobs and who can work to the standards of performance laid down by the management. This will make a contribution towards production of glass in the required quantities and quality, efficient fuel consumption and fulfilment of the planned life of the furnace.

## THE STARTING POINT

A certain amount of basic work had to be done before the training guidelines could be started. This included a job description for the furnace operator (Appendix B), a job analysis with a detailed breakdown of individual items (Appendix C) and a personnel specification (Appendix I).

The information contained in these gave a picture of the type of trainee involved and the skills and knowledge to be taught. The Board's INFORMATION PAPERS 3 and 5 give detailed guidance on how to prepare this practical information.

## Training for skill in process work

New melting methods have made physical skill less important than the ability to diagnose the cause of a problem and make a decision based on this diagnosis. The present widely accepted method of training, where the new operator works alongside an experienced man and takes corrective action as instructed by his senior, encourages the acquisition of intuitive responses to a given situation. These responses may be rapid but they are rigid and are often made without thought as to whether they are truly applicable.

With proper training, rigid intuitive responses can be replaced by reasoned reactions based on knowledge (see Appendix G). The training suggested here is devised on this principle. It is arranged under five headings and most firms will probably find it suitable to follow this pattern:

- a) induction training
- b) off the job training, in-company
- c) on the job training, possibly as an extra to normal manning
- d) off the job training, externally in a college of further education or elsewhere
- e) continuing planned experience with periods of refresher training.

## THE TRAINING PROGRAMME

### Induction

The main training programme will need to be preceded by a planned induction course. This should be designed to make the trainee familiar with his new environment and with the working conditions, both in the factory as a whole and in the furnace department (see Appendix D).

### Off the job, in-company training

Knowledge and understanding of many items related to the work can be provided off the job in a training centre, office or other area away from the production situation. Short talks in simple terms might cover the basic information and the opportunity to discuss and ask questions will give the trainee a thorough understanding of its importance. The use of simple visual training aids (Appendix J) will make this type of training more effective.

The subjects suitable for learning off the job (see Appendix E) will be selected from the job analysis.

### On the job training

The major part of the training will take place on the job under the supervision of a departmental head or an instructor acting on his behalf. The trainee will in many cases be extra to the normal strength of the work team.

For on the job training to be effective, planning should include:

- a) an examination of the job analysis
- b) a written programme of equipment to be examined, data to be recorded and interpreted, safety factors, operations to be performed and procedures
- c) a timetable, related wherever practicable to talks and demonstrations given off the job
- d) frequent appraisal of knowledge gained by the trainee
- e) a full time or part time instructor (e.g. a supervisor or experienced operator trained to instruct) (Appendix F).

### Associated further education

It is recommended that trainees should attend a suitable course to supplement in-company training and to provide a general knowledge of scientific aspects of the job. This should preferably be certificated by the City & Guilds of London Institute.

### Continuing experience

The furnace operator will continue to learn by experience but every effort should be made to ensure that he is present whenever planned, special or unusual operations are being carried out.

### THE TRAINING TIMETABLE

Individual companies will plan their own timetable but careful consideration should be given to all five of the training elements suggested. These elements need to be carefully balanced and integrated.

It is important that the timetable should enable the trainee to understand each element of the job and gradually build a comprehensive knowledge of the entire operation. This will enable him to work efficiently under both normal and emergency conditions. This principle cannot be overstressed in an occupation which requires the major part of training to be on the job.



## STANDARDS AND ASSESSMENT OF PERFORMANCE

In many cases the furnace operator is employed on shifts, usually as part of a small team and frequently working alone. He may be responsible for more than one furnace requiring different temperatures, batch loads etc. At any time he may be called upon to take emergency steps which, if taken in time and correctly, may save the company financial loss.

To ensure that the trainee has reached the required standard of competence, each stage of the training should be carefully evaluated by questioning and/or written tests and/or completion of progress reports. A feedback of results to the trainee will ensure continuing interest and self confidence. An example of a test paper is given in Appendix H.

Employers may consider providing a certificate of competence on satisfactory completion of the course, with endorsements on completion of refresher courses for qualified furnace operators.

## INSTRUCTORS

The type of instructor will vary according to circumstances - full time or part time instructors, supervisors with teaching responsibilities or experienced operator instructors. In all cases management should ensure that instructors have a comprehensive knowledge of furnace operation and are qualified to instruct, using such methods as TWI Job Instruction, taught by the Department of Employment and Productivity. Particular attention is drawn to the five day courses in TWI methods for operator/instructors. The Board's Information Paper No. 4 "Qualified to Instruct?" may also be helpful.

## THE LEARNING PROCESS

It is important that management, supervisors, technologists, technicians and established operators should all understand the difficulties of less experienced people in learning. Every effort should be made by those responsible for imparting information to understand the factors involved.

## APPENDIX A

### A - WORKING PARTY ON CRAFT OCCUPATIONS

R. H. Haigh (Chairman)	- Transport and General Workers Union.
L. Eyre	- Nazeing Glass Works Ltd.
D. Hammond	- Thomas Webb & Sons
F. K. Lax	- Lax and Shaw Ltd.
B. T. Love	- Pilkington Brothers Ltd.
D. C. Marshall	- G. H. Zeal Ltd.
G. S. Meek	- James A. Jobling & Co. Ltd.
K. Pearson	- Doncaster Technical College
D. Rider	- Glass Manufacturers' Federation
A. Wright	- Thermal Syndicate Ltd.

### B - SUB-GROUP ON FURNACE OPERATOR TRAINING

B. M. Gibbs (Chairman)	- Glass Tubes and Components Ltd.
R. L. Brown	- Monkwearmouth College of Further Education
P. Hartley	- Redfearn Brothers Ltd.
H. A. Lacey	- Triplex Safety Glass Co. Ltd.
F. K. Lax	- Lax and Shaw Ltd.
R. A. Read	- Representing Frit Manufacturers
D. A. Richardson	- Pilkington Brothers Ltd.
W. Robson	- George Davidson & Co. Ltd.
G. A. Rutherford	- James A. Jobling & Co. Ltd.
J. A. Sweeney	- Pilkington Brothers Ltd.
W. Surguy	- Glass Tubes and Components Ltd.
J. Talbert	- United Glass Ltd.

### C - BOARD STAFF

G. C. Ward	- Chief Training Officer, Glass.
S. G. Friend	- Training Adviser, Glass



FURNACE OPERATOR - MELTING

JOB DESCRIPTION

1. OBJECTIVE:

To maintain specified operating conditions in order to supply glass in quantity and to the quality determined by management.

2. OPERATIONS TO BE PERFORMED

- (a) Carry out correct take-over procedure.
- (b) Carry out correct reversal procedure where appropriate.
- (c) Read, interpret and check data from instruments and/or other sources.
- (d) Take appropriate action, if necessary, to maintain specified conditions.
- (e) Inspect furnaces internally for combustion conditions, structural condition and batch coverage.
- (f) Take appropriate action as required arising from (e).
- (g) Inspect external furnace structure and cooling systems.
- (h) Take appropriate action arising from (g).
- (i) Check glass level manually.
- (j) Ensure adequate supply of batch.
- (k) Be aware of glass quality.
- (l) Keep specified records.
- (m) Carry out emergency procedures.
- (n) Observe safe working and good housekeeping practices.
- (o) Carry out other duties as determined by management.

**APPENDIX C**  
**Part I**

**FURNACE OPERATOR - MELTING**

**JOB ANALYSIS**

Job	Skills	Knowledge	Safety
1) <u>Take-over procedure</u>	a) Ability to communicate clearly and to receive both verbal and written information.	a) Knowledge of normal running conditions.	a) Check working and surrounding areas.  b) Check protective clothing.
2) <u>Reversal procedure</u>	a) Ability to recognise quality of flame.  b) Ability to make correct decisions.	a) Regenerative principles.  b) Layout of equipment.  c) Principles of combustion process.  d) Burner design.  e) Relation between flame appearance and factors causing variation.	a) Correct sequence of reversal.  b) Emergency procedure necessitated by failure of equipment.
3) <u>Read, interpret and check data from instruments and/or other sources.</u>	a) Familiarity with instrumentation.  b) Ability to recognise trends and select appropriate action.	a) Location and operating principles of sensing and measuring devices, e.g. furnace pressure and stack draught, fuel supply, primary air temperature and flow, secondary air flow, glass level and any other instrumentation.  b) Knowledge of scheduled settings.  c) Knowledge of fuel characteristics.	a) Safety precautions and dangers with various types of fuel.  b) Radiation dangers.  c) Electrical precautions.

**APPENDIX C**  
**Part I**

Job	Skills	Knowledge	Safety
4) <u>Take appropriate action</u>	a) Recognition of normality and deviations. b) Ability to make fine adjustments.	a) Limits of responsibility for any action taken. b) Knowledge of components of all systems. c) Operating principles of adjusting devices. d) Interaction of variables. e) The time lag in effect of adjustments.	
5) <u>Inspect furnace internally</u>  a) Combustion conditions.  b) Batch coverage  c) Bubblers  d) Electric boost-water in-leakage from electrons or water boxes.  e) Structural conditions	a) Ability to assess and interpret flame appearance and firing conditions.  b) Ability to assess and interpret batch distribution and level.  c) Ability to assess and interpret bubble rate and appearance. Reading of flow gauges.  d) Recognition of effect of leakage.  e) Ability to assess changes in furnace superstructure; in particular, corrosion, surface breakage, movement of joints, deposits.	a) Principles of combustion and heat transfer etc. (as reversal : check firing).  b) Factors affecting batch distribution; effect of variations on melting. How to obtain correct distribution pattern.  c) Layout and operation of system. Effect on bottom wear and temperature distribution.  d) Causes of leakage. Effect on structure.  e) Design and construction of furnace, mechanism of corrosion, routine of inspection - key positions.	Protective equipment - gloves and furnace glass. Sting out dangers.

**APPENDIX C**  
**Part I**

Job	Skills	Knowledge
<p>6) <u>Corrective action following internal inspection</u></p> <p>a) Combustion conditions</p> <p>b) Batch coverage</p> <p>c) Bubblers</p> <p>d) Water in leakage</p> <p>e) Structure</p>	<p>a) Ability to adjust flames and air correctly. Setting of burners and changing of burners.</p> <p>b) If appropriate - ability to carry out removal of charger, cleaning and replacement.</p> <p>c) Adjustment of bubbling rate.</p> <p>d) Ability to handle controls correctly and quickly.</p> <p>e) Ability to carry out simple hot repairs. Correct choice of material.</p>	<p>a) Combustion principles. Operation and layout of combustion system, burner design and operation.</p> <p>b) Operation of charging system.</p> <p>c) Layout and operation of system.</p> <p>d) Layout of system - correct routine to follow.</p> <p>e) Correct routine (e.g. advising supervision). Limits of action. Properties of refractories.</p>
<p>7) <u>External structure</u></p> <p>Corrective action</p>	<p>Recognition of changes in condition of furnace structure e.g. cracks, movement, hot spots, condition of steelwork and cooling systems and ancillary equipment as appropriate.</p> <p>As for internal inspection.</p>	<p>Design and construction of furnace.</p> <p>Correct routine to follow - key points to note.</p>
<p>8) <u>Manual check of glass level</u></p>	<p>Ability to handle equipment.</p>	<p>Correct level. Effect of variations on process and glass quality.</p>
<p>9) <u>Batch supply : check level</u></p>	<p>Judgment of batch level in hopper.</p>	<p>Correct level. Effect of variations.</p>
<p>10) <u>Refill hopper</u></p>	<p>Handling equipment. Judgment of level in hopper. Recognition of correct material.</p>	<p>Make-up of batch. Effects of segregation.</p>

**APPENDIX C**  
**Part I**

Job	Skills	Knowledge
<b>11) <u>Emergency procedures</u></b> e.g. failure of fuel air water steam fire glass  <b>Personal accidents</b>	Familiarity with locations of main shut-off valves for all services, alarm systems, ability to operate emergency equipment as appropriate.	<p>Procedure to follow for each emergency. Correct use of emergency equipment. Correct re-starting procedures on return to normality.</p> <p>Procedure for reporting and recording emergencies, accident and fire details.</p>
<b>12) <u>Keeping records</u></b>	Ability to keep and understand all instrument records necessary. Ability to make suitable written communication of e.g. abnormal conditions (see "Take over Procedure").	Recording procedure for each variable. What special points should be noted. Importance of reliable records as part of information service to management.
<b>13) <u>Awareness of glass quality</u></b>	<b>Recognition of acceptable glass quality.</b>	Effect on glass quality, of variation in temperature, batch conditions, etc., and of furnace wear. Effect of variation in glass quality on the forming process. Operating limits specified by management.

**NOTE: - Examples of two detailed Job Analyses are given in Part II**

APPENDIX C  
Part II

JOB ANALYSIS - EXAMPLE No. 1

JOB	STAGES	KEY POINTS	SAFETY	SKILLS	KNOWLEDGE
<u>REVERSAL</u> <u>PROCEDURE</u>	1. Cut off fuel to firing side (plus any related adjustments).	Time (or temperature).			Understanding of regenerative principles.
	2. Reverse flow of secondary air.	Check movement of valve.	Correct sequence.		Detailed layout of furnace control valves and equipment.
	3. Feed fuel to opposite side (plus any related adjustments).				
	4. Check fuel flow.	Check flow indicator.			
	5. Check firing.	1. Idle burners off. 2. Flames for length and distribution of fuel through observation holes. 3. Flame roots for appearance and form (especially condition of burners) and firing angle.	Sting out dangers. Use of gloves. Use of safety glass.	Recognition of correct and incorrect flames and overall firing condition.	Understanding of principles of: 1. Combustion process. 2. Burner design and atomisation. 3. Relation between flame length, flame appearance, fuel flow, atomising air (or steam) flow and secondary air flow.



**APPENDIX C**  
**Part II**

**JOB ANALYSIS - EXAMPLE No. 2**

JOB	STAGES	KEY POINTS	SAFETY	SKILLS	KNOWLEDGE
READ, INTERPET, INSTRUMENTS.	1. Know specified or expected temperature.				
a) Furnace Temperature.	2. Read temperature as indicated or recorded.	<p>If as expected - no action.</p> <p>If different from expected - is this consistent with furnace firing and/or indications or recordings of other related instruments?</p> <p>If yes - take appropriate action.</p> <p>If temperature is inconsistent or doubtful, check:-</p> <p>1. by independent means e.g. D.F.P.</p> <p>2. reliability of temperature indicator or recorder.</p>			<p>Furnace temperature cannot change instantaneously.</p> <p>Principles of operation of temperature sensing devices (e.g. thermocouples, radiation pyrometers etc.)</p> <p>Location of temperature sensing devices.</p>
	3. Check tempera- ture if necessary.				

## APPENDIX D

### INDUCTION COURSE

It is important that during an individual's early employment the use of short induction courses should be encouraged. The course is designed to familiarise the trainees with their general environment and the overall working conditions and it might consist of much of the following:

1. Working rules and conditions. Company rules and regulations. Factories Act. Time keeping. Hours of work. Areas of supervision and responsibility.
2. Welfare - sickness and pension benefits. Travel and holidays. Committees. Social and sports club. Canteen.
3. Pay and conditions - how pay will be made up. Stoppages, PAYE. How and where he is paid. Where he can query the make up of his pay.
4. Safety - workshop safety and relevant legislation. Hygiene and industrial health. Accident prevention and occupational hazards. Elementary first aid and location of facilities. Lifting and carrying. Reporting accidents.
5. Consultation and negotiating arrangements. Trade unions, shop stewards. Grievances and disputes procedure. Joint productivity councils. Workmen's inspection.
6. Promotion possibilities. What is possible. What is available - training and education courses. Encouragement.
7. The importance of the job. The company, its products and achievements. Where the products go; how they are used. What it means to the country. Where he fits in the company. What his part means to the whole.
8. Geography. Tour of the works. The working place. The relevant offices. The facilities. The appropriate supporting service department.
9. Introduction to the furnace department.

RECOMMENDED SYLLABUS OF TALKS AND DEMONSTRATIONS

1. Introductory lecture
  - a) Outline of training programme
  - b) Scope of firm and industry
  - c) Outline of furnace operation
2. Nature of glass
  - a) Properties and composition
  - b) Uses of glass
3. Raw materials
  - a) Types
  - b) Sources
  - c) Preparation
  - d) Effects on glass properties
4. Melting
  - a) Process
  - b) Inter-relation between variables
  - c) Refining and conditioning
  - d) Combustion principles
  - e) Regeneration and recuperation
  - f) Heat conservation
5. Furnace construction and furnace operation
  - a) Refractory materials: types, properties, uses, heating
  - b) Furnace design: choice of materials etc.
  - c) Principles of construction: blocks and brickwork, steelwork.
6. Fuel systems and fuels
  - a) Types of fuel
  - b) Burners
  - c) Systems
7. Glass flow
  - a) Temperature distribution
  - b) Furnace shape

8. Instrumentation

- a) Variables and interpolation
- b) Types and operation
- c) Sensing devices, indicators
- d) Settings
- e) Controllers
- f) Recording and communication procedure - other furnace operators/supervisors

9. Ancillaries

- a) Stirrers
- b) Bubblers
- c) Cooling systems
- d) Electric boost

10. Procedures

- a) Routine
- b) Specially planned shutdowns
- c) Emergency

11. Safety and Fire Prevention

- a) Personnel safety
- b) Fire prevention and firedrill
- c) Accident prevention

ON THE JOB TRAINING

1. Objective

To develop knowledge of normal working conditions

Routine

A specific routine must be built up so that the observation is systematic. At the end of the training period the trainee should be familiar with the layout of the furnace and the location of points of observation.

- a) Tour with instructor or competent person. The trainee will be shown where to observe the various phenomena. At this stage little attempt should be made to involve the trainee in observation and diagnosis. The object is to get him to discover where to go to make the observation.
- b) Second tour. This time the trainee conducts the tour and at each point he should tell the instructor what he is to look for.

If the trainee has not mastered the whole routine after two tours the instructor should note where the trainee's difficulties lie for further attention, but at this stage it would be more beneficial to change the subject to something more specific.

Looking into the furnace

There is an art in this and because of the conditions it can only be done for short spells.

Experience has shown that if the learner is asked questions like: "Can you see where the glass reaches the far wall, there is a dark patch on the surface?" he will often say "yes" when he has not in fact seen it. A far better method of posing the question would be to say: "Look at the surface of the glass where it touches the far wall - what does it look like?"

In this way the instructor should ask the learner to describe the appearance of the interior of the furnace.

In order to rest from observation, the instructor should take the trainee to look into the furnace from several points. If he follows the specific route laid down under "Routine" this will reinforce his developing knowledge of the layout and observation points.

### Instrumentation

Again in the first day a change of pace can be brought about by having a session on instruments.

The instructor should briefly recapitulate on the knowledge of instrumentation the trainee has gained off the job. Emphasis once more should be laid on the interdependence of the parameters and the linking of instruments. Faced with an instrument panel the trainee should learn to identify each instrument and associate it with the position of the sensing device in the furnace. This can best be done by question and answer techniques on the spot.

### Observation and recording

The trainee can then be sent off on his own to fill in a questionnaire devised by the instructor, roughly as follows:-

1. Position of observation \_\_\_\_\_
2. Describe surface \_\_\_\_\_
3. Describe appearance  
of flames \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
4. Describe appearance  
of furnace walls etc. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

On his return the instructor can check the questionnaire and go over points missed out or not clearly described.

Incidentally, this exercise should develop the trainee's skill in written communication.

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## 2. Objective

To develop recognition of deviations from normality

### Observation

This is the most difficult section in which to provide training. The chances of providing first hand experience in all possible deviations from normality in the first few days of training are extremely slim. However, there is no real substitute for this kind of experience unless one goes to the extent of building a simulator. One can do everything possible to provide explanations liberally illustrated with visual aids. It is perhaps possible



to ensure when things do start to deviate from normal that the trainee is afforded every opportunity to see what is going on. His experience should be a planned and not a random affair.

### Record of planned experience

To ensure that the trainee's experience is not a random affair, a record of all experience he has undergone on the furnace should be made. This is so that the instructor will be able to judge when the trainee is ready to undergo the diagnostic and decision taking form of training.

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### 3. Objective

To ensure that the trainee is capable of carrying out standard operations.

#### Manual

A manual of standard operations should be drawn up. This should be split into three sections:

- a) Routine or on-line operations. Operations which take place every day as a matter of course, e.g. reversals, changing burners.
- b) Special operations. Operations which only take place occasionally but which are a normal part of furnace operation and which can be planned in advance, e.g. ring change, bubbler changes.
- c) Emergency operations. Operations which are necessary to deal with sudden contingencies, e.g. burst water boxes, collapse of superstructure, failure of services.

Normally the only way a person learns how to deal with these things is on the actual job. In the case of emergencies he goes through the stages of being told to stand aside, being useful to clear up afterwards, doing odd jobs at someone's command and so on.

With a manual the trainee can often anticipate what will be required of him. This is particularly true if exercises in these procedures can be arranged beforehand. There is no suggestion that exercises are a complete substitute for the real thing, but experience shows that they are a very valuable form of training.

TRAINING FOR SKILLS - diagnosis and decision making

If we can assume that the trainee has acquired the knowledge he needs off the job and has gained the experience on the job to recognise certain situations, he will still need training to teach him to picture the process mentally and use the rules of logic and rational thinking to solve problems.

This could, of course, be done by providing a period of observation of the process under the personal tuition of the instructor. It would however take a long time before the necessary experience of every situation could be gained. A better but more expensive method would be to build and use a simulating device. In the absence of simulators it still should be possible to devise theoretical problems taking examples from the process to provide the trainee with experience in problem solving.

These exercises should be aimed at making the operator think out the solutions for himself and not provide him with rigid rules for dealing with specific problems.

The following example is taken from the flat glass industry.

Occurrence

You observe, through the melting end sight hole, that the blanket has swung towards the left-hand side of the tank and that individual logs have broken off and are passing through the normal hot-spot, firing from left to right.

Question One - Motivation

What is likely to happen if this situation is unchecked?

Logical Answer

- a) L/h side is likely to be colder than the r/h side.
- b) L/h regenerator will be colder, the r/h regenerator will be hotter than normal
- c) L/h regenerator will not be pulling out exit gases efficiently.
- d) This leads to an increase in tank pressure localised in the middle section and working end of tank, when firing from R. to L.

On reversing - firing from L. to R. - there is a sudden decrease in pressure due to the increased pull of the hot regenerators.

- e) When tank pressure is high the working end gets warmer than it should. The cooling air controlled by the immersed thermocouple increases.
- f) Then the tank reverses and the pressure drops. In addition to the more than normal rate of cooling, a negative pressure in the tank results in an inrush of air at all the holes in the working end.
- g) This leads to chilling of the glass, particularly at the sides and on the surface.
- h) This leads to highly unstable conditions, fluctuating wildly on reversals, and uneven temperature distribution across and in the depth of the glass.
- i) This makes it impossible to control sheet formation, annealing, distortion, etc.

#### Question Two - Analysis of trouble

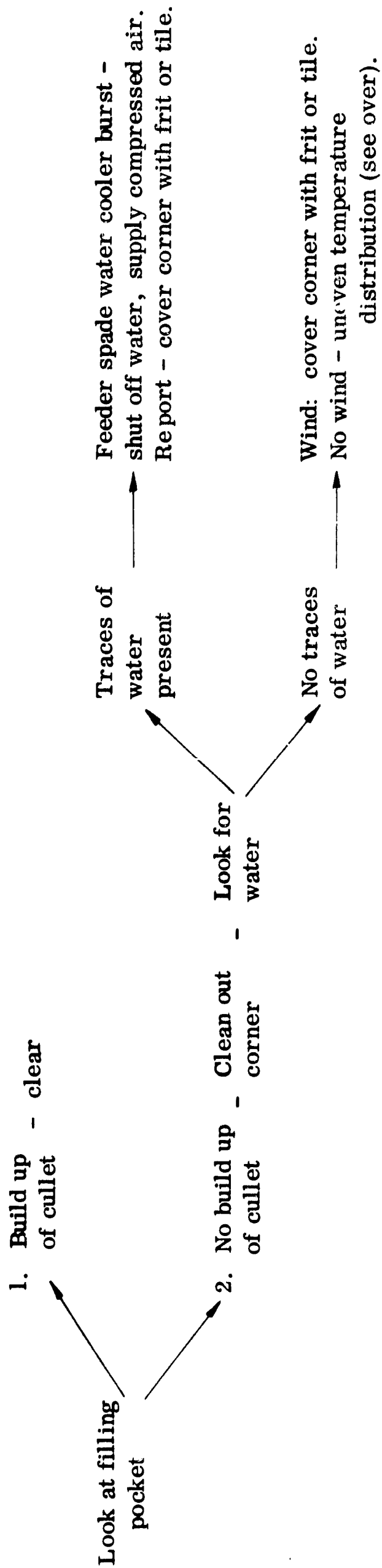
What causes the blanket to swing?

- a) One corner of feeding pocket too cold
  - Wind on corner.
  - Build up of cullet.
  - Feeder spade cooler burst.
- b) Initial uneven distribution of tank temperature
  - Deficient burners.
  - Damper tiles broken.
  - Damper tile water cooler box burst.
  - Side wall water box burst.

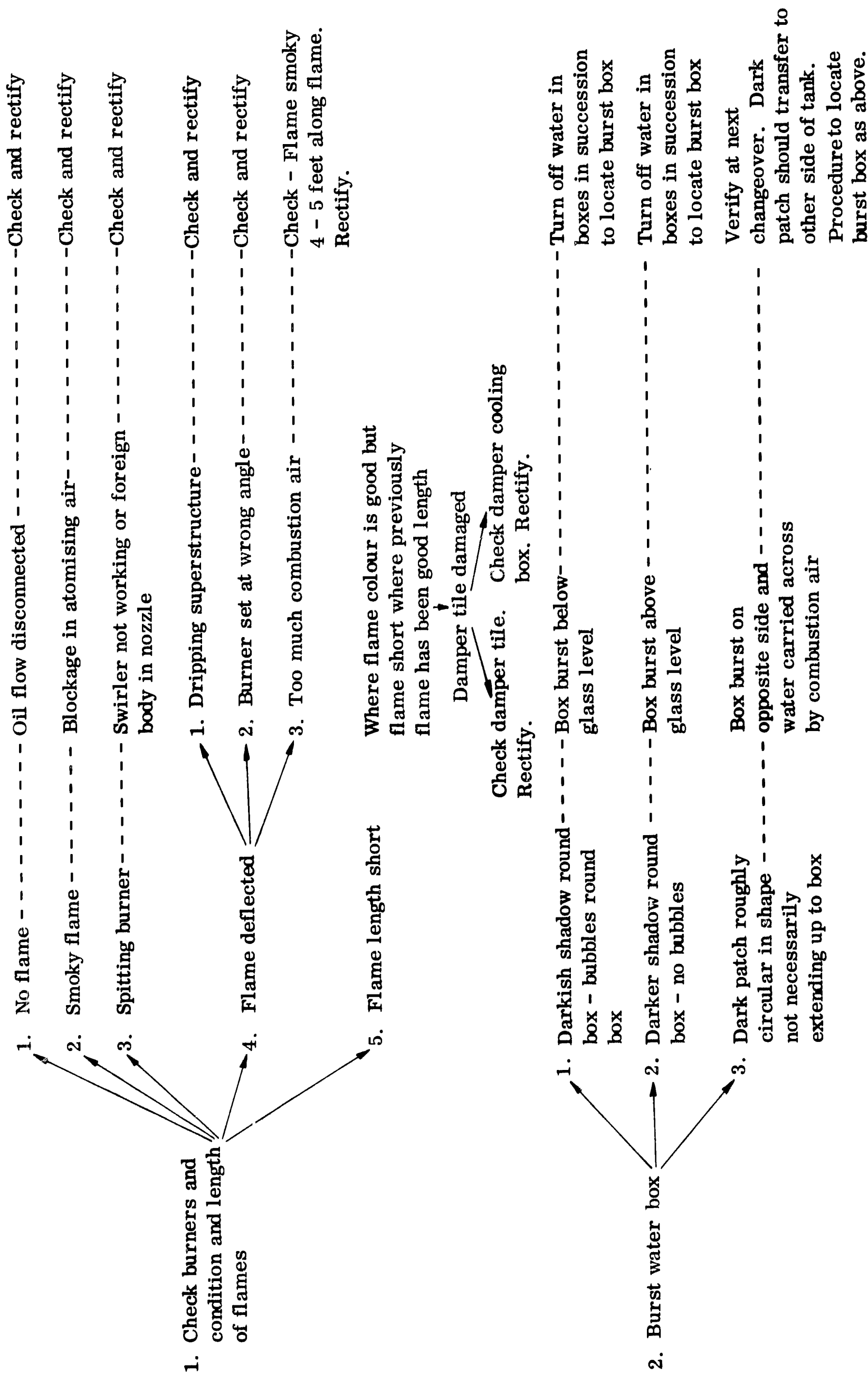
#### What Action Must Be Taken? - Diagnosis and Decision Making

- a) Feed cullet into hot corner to cool down that side of tank and draw blanket towards centre.
- b) Diagnose trouble - see example (A) COLD FILLING POCKET  
(B) UNEVEN TEMPERATURE DISTRIBUTION.

**EXAMPLE A - COLD FILLING POCKET**



## EXAMPLE B UNEVEN TEMPERATURE DISTRIBUTION



EXAMPLE OF WRITTEN TEST PAPER

Instructions

There are a number of questions on this paper with three possible answers, (a), (b), or (c). Ring round the answer which you think is the correct one.

RAW MATERIALS

1. It is possible to make glass out of only one of the raw materials normally used. Which is it?
  - (a) Soda ash
  - (b) Limestone
  - (c) Sand
2. Soda is used in glassmaking:
  - (a) Because it hardens the glass
  - (b) It makes the glass clear
  - (c) It helps to melt the sand
3. If we made glass out of sand and soda only the glass would be:
  - (a) Difficult to melt
  - (b) Weathered too easily
  - (c) Coloured
4. The percentage of lime in the average soda-lime-silica glass is:
  - (a) 14%
  - (b) 9%
  - (c) 72%
5. If we added 30% lime to the batch the resulting glass would be most likely to contain:
  - (a) Seed
  - (b) Devitrification
  - (c) Batch stones

MELTING

1. Glass is:
  - (a) A crystalline substance
  - (b) A super cooled liquid
  - (c) A metal



2. Glass has:

- (a) A melting point of  $1500^{\circ}\text{C}$
- (b) A melting point of  $600^{\circ}\text{C}$
- (c) No melting point at all

3. The most difficult of the three major raw materials to be assimilated in the batch melting process is:

- (a) Sand
- (b) Soda ash
- (c) Limestone

4. The boundary line between unmelted batch and clear glass (flux line) should be positioned:

- (a) At the hot spot
- (b) Half way between hot spot and bridge wall or flying arch
- (c) At the filling side of the hot spot.

### **SAFETY**

Several questions should be designed concerned with safety factors involving persons, plant and equipment and should include reference to fire hazards.

## APPENDIX I

### PERSONNEL SPECIFICATION - FURNACE OPERATOR

(Note: The following is for guidance only, for adaptation to individual circumstances).

1. PHYSIQUE

Good standard of health and fitness, good vision (including colour) and hearing. Average degree of strength, ability to withstand noise or heat, fairly long periods of standing, able to work safely at heights.

2. ATTAINMENTS

Literate and capable of clear self expression - verbal and written. Previous experience not essential but evidence of stability in previous jobs is desirable.

3. GENERAL INTELLIGENCE

Average.

4. SPECIAL APTITUDES

Some appreciation of simple mechanical principles.

5. OUTSIDE INTERESTS

Should not tend to conflict with shift work requirements (e.g. team sports).

6. DISPOSITION

Must be dependable, self reliant and conscientious. Acceptability to others important but should be able to work alone when necessary.

7. CIRCUMSTANCES

Preferably married - 30 to 50 years old, willing to work shifts and willing to work suitable hours to ensure continuity of coverage of furnace operations.

## APPENDIX J

### LIST OF SUGGESTED TRAINING AIDS

Photographs on cooling before repair, furnace construction etc.

Wooden models of furnaces.

Examples of refractories.

Control charts.

Examples of instruments.

Diagrams.

Glass samples, showing (a) glass faults due to furnace operation,

(b) finished product (illustrating seed,  
stones, cord, colour).

Burners/burner mountings.

Films - the following include useful 'shots' of furnace operation.

"Well I'm Blowed" - 16mm sound/colour - 24 minutes, obtainable  
from:

Sound Services Library,  
Wilton Crescent,  
Merton Park,  
London, S.W. 19.  
01 - 542 7201

"Glassmakers" - 16mm sound/colour - 18 minutes, obtainable from:  
Sound Services Library.

"The Manufacture - 16mm sound/colour - 27 minutes obtainable from:  
of Glass" Sound Services Library.

"Glas"(Dutch Film) 16mm sound/colour - 11 minutes, obtainable from:

Contemporary Films,  
14 Soho Square,  
London, W.1  
01-437 6693

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