

**Fundamentals of Fitting – Course: Techniques of Fitting and
Assembling Component Parts to Produce Simple Units. Methodical
Guide for Instructors**

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Fundamentals of Fitting – Course: Techniques of Fitting and Assembling Component Parts to Produce Simple Units. Methodical Guide for Instructors

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1. Objectives and Subject Matters of the Practical Vocational Training in the Techniques of “Fitting”

On completion of the training the trainees are supposed to have a good command of the manual techniques of fitting component parts, in order to produce simple units.

To achieve this, the following is required:

Objectives of training

- The trainees have knowledge of the purpose, types and use of the fitting of component parts and sub-assemblies (units).
- They know the various methods used for manual fitting works in preparation of assemblings.
- They are able to produce the correct type of fit according to the use and function of the component parts and sub-assemblies.
- The trainees are able to properly select the tools and auxiliaries and to suitably apply them by strictly observing the health protection, labour safety and fire protection rules.

To meet these objectives, the instructor or teacher should emphasize the following points of content:

Subject matters of training

Knowledge

- purpose, types and methods of manual fitting works
- types and fields of application of the tools, testing instruments and auxiliaries
- selected basic terms of the ISA System of Fits, representation and designation of fits
- principal technological sequences of fitting works on plane and curved surfaces
- hints on labour safety

Skills

- selection and handling of the tools, testing instruments and auxiliaries for manual fitting works

– selection and implementation of the appropriate technique according to the demands made on the work–pieces:

- narrow, plane surfaces by filing
- broad, plane surfaces by filing and scraping
- curved surfaces by scraping
- bores by reaming
- quality control and function test.

2. Organizational Preparation

All instructions, demonstrations and exercises should be prepared thoroughly and meticulously.

This requires the following measures:

2.1. Planning of the Practical Vocational Training in the Techniques of “Fitting”

Draw up a time schedule and set an approximate number of hours in which you expect to complete the instruction on the various techniques of fitting. Plan an appropriate number of hours for the theory instruction on each subject, the practical demonstration, the instruction in preparation of a particular job, especially the exercises, the proper execution of the exercises, for recapitulations and controls.

When elaborating your time schedule, remember the level of know–how of your trainees, the conditions of trainees, the jobs which your trainees will take on in future and the degree of difficulty of the respective training stage.

The emphasis at each stage of training is always on the impairment of high craftsmanship and teaching of mechanical skills with the help of practice–related exercises which should be given the biggest chunk of time your schedule–

2.2. Preparation of the Labour Safety Instructions

A short labour safety instruction should precede every practical exercise, where the main points of the safe handling of all tools, auxiliaries, etc. are explained to avoid injuries. The directions which are binding on the safe handling of drills, countersinks and reamers should be repeated as they apply to the techniques of fitting. The following focal points should be repeated several times:

- Make sure that all tools are clean, sharp and undamaged.
- Make sure that the workpiece is clamped securely and safely. Never apply excessive force. This may damage the workpieces.
- Put all measuring and testing means aside at their proper place. Use pads, supports, etc. where provided, to protect them against impact, shock and corrosion.
- It is regarded as good workmanship to keep one’s workplace tidy and always to put down individual components together with their matching parts.

Have a notebook or file at hand where you keep minutes of these instructions. All trainees shall certify with their signature that they were instructed accordingly.

2.3. Preparing the Teaching Aids

- The “Trainees’ Handbook of Lessons – Fundamentals of Fitting” has to be given to each trainee.
- Surveys can be prepared in form of blackboard drawings prior to the beginning of the instructions.

- Component parts, assemblies and models of guides can be made available as demonstration aids.

2.4. Preparing the Working Materials

- Each trainee has to be given the “Instruction Examples for the Practical Vocational Training – Fundamentals of Fitting” as theoretical basis for the exercises to be done.
- The starting material necessary for the exercises has to be prepared with the help of the material contained in the “Instruction Examples...” and made available in a sufficient number.
- The workshop has to be checked for complete equipment with tools, measuring and testing means and auxiliaries according to the planned exercises.
- Recommended basic equipment:
 - hand hacksaws, files of various forms, scrapers, hand reamers with and without angular momentum
 - steel scribe, pencil, centre punch, hammer, aluminium hammer
 - limit gauges for external and internal dimensions
 - form gauges and feeler gauges, centre squares
 - steel tape, vernier caliper, external, internal and depth micrometers, protractor
 - marking devices
 - marking colour, chalk, cutting oil, tap wrench, machine grease
 - vice with protective jaws, special clamping devices
- A bench or upright drilling machine with pertinent clamping devices is required for the necessary preparatory works (boring and countersinking),
- Prior to the beginning of the exercises, the serviceability of this machine has to be controlled with regard to the aspects of labour safety.

3. Recommendations for the Practical Vocational Training in the Techniques of “Fitting”

The following paragraphs make suggestions for the theory instructions, demonstrations of the techniques of fitting, as well as for checking and assessing the trainees’ newly acquired know-how.

3.1. Introductory Instruction

The trainees should be instructed on the basics of the subjects. For this, use a room where they can sit down and take notes. The trainees should be asked to enter the answers to the questions in the “Trainees’ Handbook...”. The trainees are supposed to have a good command of the techniques of filing, scraping and reaming before they are instructed in the techniques of fitting. The essentials of these techniques should be repeated occasionally. The contents of the “Trainees’ Handbook...” follow the system of the introductory demonstrations and instructions. The focal points in that “Handbook” can be discussed in the order given there.

Purpose, types and methods of manual fitting works

To start with, explain to the trainees the necessity of fitting works in preparation of mounting sub-assemblies.

It is advisable, to show examples of interference and clearance fits by means of visual aids available and to explain the use of these types of fits.

Since the methods applied in manual fitting works differ strongly in individual and series production these differences have to be illustrated by examples.

In doing so the manufacturing condition of “exchangeability” of series–manufactured component parts has to be especially pointed out.

Tools, testing means and auxiliaries

Introduce the tools, testing means and auxiliaries, as well as the fields of their application. The trainees will have some knowledge from their instructions on the manual techniques of material working. Discuss these points again with your trainees. Ask them questions to find out what they remember.

The following instruments are to be recapitulated:

- files, scrapers, hand reamers
- matching pieces, testing instruments, measuring instruments
- marking devices
- special clamping devices, vice with protective jaws.

Selected basic terms of the ISA System of Fits

The worldwide use of the ISA System of Fits, particularly in countries which have adopted the metric system of units makes it necessary to enable the trainees to work with ISA–standardized sub–assemblies. With the help of the respective section in the “Trainees’ Handbook...” basic terms can be explained which have to be known for reading an engineering drawing with fit specifications.

Only selected terms from this extensive field are to be mentioned:

- nominal size and actual size
- dimensional limits, dimensional variations and fit sizes
- tolerance and tolerance zone.

Accordingly, the representations of fits in engineering drawings have to be shown, and “fit specifications with dimensional variations” and “fit specifications with ISA symbols” have to be presented.

Imparting of this knowledge should be aimed at recognizing fit specifications in engineering drawings and deducing their fabrication with corresponding tools and testing means.

For the practical work it is not necessary to calculate the dimensional limits by means of ISA tables. However, the trainees should be shown such a way of determining a dimensional limit by the example of a “fit size symbol”.

This focal point has to be concluded with the explanation of the advantages of the ISA System of Fits. It should be especially emphasized how simply precision bores can be worked manually using ISA–standardized hand reamers and testing instruments the dimensions of which have been coordinated accordingly.

Fitting works on plane and curved surfaces

The various techniques are to be explained proceeding from the description of the working surfaces of component parts and sub–assemblies.

The “Trainees’ Handbook...” contains pertinent examples:

Fitting works on narrow plane surfaces are described by the example of a mitre angle gauge, the working of broad plane surfaces is explained by examples of a square–box wrench and a lock screw. Precondition for this is the good command of the techniques of “filing” and “scraping of plane surfaces”.

When explaining these works the different test methods are to be dealt with.

It is important to show the trainees the limits of the light gap test method and to explain to them the drag mark and the touching-up method as supplementary and more exact test methods.

Recommendation:

Here, the instructions can be finished and followed by exercises in the working of plane surfaces (1st and 2nd Instruction Examples).

Subsequently, the instructions have to be continued by the following focal point:

Fitting works on curved surfaces are also described by means of examples.

The fitting in by scraping of a slide bearing and the reaming of a gear bore for the reception of a shaft are explained. The latter example requires the recapitulation of the knowledge of the point "ISA System of Fits" and an explanation of the practical application. It is recommended to determine a fit size as example to designate tools and testing means with concrete specifications.

Hints on labour safety

The main points of safe filing, scraping and reaming should be discussed once more. These main points can be taken from the "Trainees' Handbook of Lessons".

3.2. Exercises

The necessary hints on labour safety have to be given, on principle, before the beginning of the exercises.

Afterwards, the workshop and the available technical equipment are to be shown to the trainees and their operation is to be demonstrated. It is recommended that the instructor begins each exercise with a demonstration in connection with instructions related to the given instructional example. The trainees are to be motivated to perform the exercise in good quality. Expected difficulties have to be pointed out.

The exercises can be done either as a compact whole according to the recommendations mentioned in Section 3 or in two exercise stages.

By means of the "Instruction Examples for the Practical Vocational Training – Fundamentals of Fitting" four exercises can be performed by using different techniques of fitting.

The "Instruction Examples for the Practical Vocational Training – Fundamentals of Fitting" contain a list of the material (starting material, tools, measuring and testing means and auxiliaries), the sequence of operations for doing the exercises and a comprehensible workshop drawing. This provides the trainees with the information necessary to perform the exercises purposefully.

If the course of the exercises shows that the quality of the practising workpiece is insufficient, more extensive exercises will have to be done. In this case, any waste products should be used. After the trainees have sufficiently proved their skills with these products, the envisaged Instruction Example can be manufactured.

It is necessary that the instructor previously produced the practising workpiece by himself so that he knows all the problems of the manufacturing process.

Thus it is possible to name clear main points for evaluating the performances – problematic points of the practising workpiece can be pointed out. During the task-related instructions the sequences of operation and workshop drawings should lie on the tables so that the trainees can take down notes into their handbooks.

The individual Instruction Examples are shortly described in the following to give a survey of the practising workpiece to which the previously imparted knowledge should be applied:

Instruction Examples

Instruction Example 31.1. Mitre Angle Gauge

A testing means is made of a 2-mm-thick steel sheet by filing an angle sector of 135°. The fit test is performed with the light gap test method by means of an available angle gauge or a protractor.

(Figure 1)

Instruction Example 31.2. Square Bolt for a Three-jaw Chuck Wrench

A square with a wrench opening of 12 mm is filed to a round stock with a diameter of 16 mm. The accuracy of the fit is tested with a square bush of corresponding size of a three-jaw chuck. The drag mark method is used as test method.

(Figure 2)

Instruction Example 31.3. Lock for Three-jaw Chuck Wrench

The pre-fabricated square bolt is now being equipped with a head and a lock. The fitting work is performed by reaming with ISA-standardized hand reamers. The required pin joints are to have clearance and interference fits. Limit gauges are used to test the fit.

(Figure 3)

Instruction Example 31.4. Pulley and Shaft to be Fitted together

An available pulley is joined with a pre-fabricated shaft. The bore of the shaft has to be adjusted according to the desired fit size – the subsequent mechanical treatment is performed by reaming. The feather key is to be inserted into the shaft keyway, if necessary it has to be pre-worked by filing true to size.

(Figure 4)

All trainees can do the exercises simultaneously, provided that the material prerequisites are guaranteed (availability of a sufficient number of devices).

In this case, the trainees can individually carry out the exercises – each trainee should be given as much time as he needs.

If there are not enough working tools available, the trainees will have to be split up in groups. It is favourable to divide them into groups according to the use of the various tools, measuring and testing means.

If the suggested Instruction Examples are not used for the exercise, it will also be possible to select other practising workpieces. The instructor should take care that all techniques previously discussed can also be practised with these pieces.

Major points as to practical work

It is advisable for the instructor to select certain aspects which he will give his particular attention when supervising and evaluating the trainees' exercises. Here are a few suggestions:

- Do the trainees carefully prepare the workplaces?
- Do they select the proper tools (size, form) for the fitting works?
- Do the trainees recognize the fit sizes from the engineering drawing?
- Do the trainees adhere to the correct sequence of the fitting works?
- Do the trainees correctly apply the test methods?
- Do the trainees meet the quality requirements?
- Are the trainees able to correctly assess the quality of their work?
- Do the trainees observe the labour safety rules?

The main points of evaluation have to be made known to the trainees prior to the beginning of the exercise!

3.3. Examples for Recapitulation and Control

This section contains tasks for consolidating and testing the acquired knowledge and skills; the answers to each task are also given:

1. What is the purpose of fitting?
(To assemble component parts, according to their function, to sub-assemblies.)
2. Which types of fits are mainly distinguished?
(Interference and clearance fits, cylindrical and flat fits.)
3. Which methods can be applied in fitting works?
(Individual or single-piece production and series production.)
4. Which manufacturing condition is good for an efficient economic assembling?
(The elements belonging together according to their function have to be exchangeable.)
5. Which tools are used for manual fitting works?
(Files, scrapers, hand reamers.)
6. Why has the internationally valid ISA System of Fits been adopted?
(To render possible the international exchange of ready-to-assemble component parts and sub-assemblies.)
7. Which specifications have to be recognizable in an engineering drawing?
(The permissible dimensional variations have to be given in form of numbers or symbols.)
8. How is the specification of an ISA fit size marked?
(Nominal size specification, tolerance zone and quality number.)
9. Which practical importance does the application of the ISA System of Fits have for testing?
(Standardized gauges make possible a time-saving testing of the quality of the fit without determining the actual size.)
10. Which recommendation has to be paid attention to during the testing?
(Testing means and workpiece must have the same reference temperature.)
11. What does "shift-fitting" mean?
(A symmetrical element has to fit into the matching piece also in case of a rotation of 90° or 180°.)

4. Teaching Aids

For a better understanding by the trainees it is recommended to make available demonstration objects.

These can be component parts and smaller sub-assemblies of machines, but also self-made models of flat tracks, dovetail guides and cylindrical guides. It is also favourable to use prepared practising workpieces in the instructions (on the basis of the "Instruction Examples...") to demonstrate good and bad fitting work.

If the trainees are to be familiarized more profoundly with the ISA System of Fits, it is recommended to prepare blackboard drawings or transparencies for overhead projection with extracts from ISA tables and representations of fits.

Likewise, such teaching aids can also be derived from national standards.

