

**Bending – Course: Technique of Working Sheet Metals, Pipes and Sections. Methodical Guide for Instructors**



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# **Bending – Course: Technique of Working Sheet Metals, Pipes and Sections. Methodical Guide for Instructors**

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## **1. Aims and Contents of Practical Vocational Training in the Techniques of Bending**

After having terminated their training, the trainees shall be able to surely master the most common techniques of bending procedures. For that purpose, the following aims have to be achieved:

### ***Aims***

- The trainees will have profound knowledge of kinds and fields of application of the working means to be used for bending.
- They will master the different techniques to be used for bending sheet metals, pipes and sections with various tools, appliances and machines.
- They will be enabled to select the appropriate working means according to the kind of material, material thickness and shape of bending.
- The trainees will be capable of adequately employing the tools, appliances and machines while adhering to the health, labour safety and fire protection regulations.
- They will know how to assess the quality of their work themselves.

To reach the objectives so demanded, the following subject matters have to be imparted by the instructor

### ***Contents***

- Knowledge:
  - Purpose of bending
  - Kinds and fields of application of tools, appliances and machines
  - Phenomena occurring in the material
  - Fundamentals of calculation
  - Bending techniques
- Hints on labour safety
- Skills:
  - Folding, aiming over, flanging, seaming, crimping, rounding of, and rolling of sheet metals

- Rounding of sections and pipes
- Rolling of sections

## 2. Organizational Preparations

To ensure a trouble-free course of instructions, exercises, and vocational practice, it is necessary to prepare the training well, with the following measures to be taken:

### 2.1. Planning the Training in Bending Techniques

Proceeding from the total hour volume, the times for the individual training sections of this vocational unit should be planned in a differentiated manner.

It is recommended to draw up a time schedule for the subsequent training sections:

- for introducing the techniques in the form of instruction
- for necessary demonstrations
- for instructions to prepare the practical exercises
- for executing the practical exercises
- for recapitulation and controls.

While the hours are being scheduled, the following additional factors are to be taken into consideration:

- the trainees' educational level
- the training conditions
- the trainees' future employment
- the degree of difficulty of the training section.

The focus of each training section is always the acquaintance of practical skills and abilities by exercises, which will take the most comprehensive period of time.

### 2.2. Preparing the Instructions on Labour Safety

Before the practical exercises begin, the trainees are briefly instructed on the adequate handling of working means and given recommendations for an accident-free work. In general, those regulations are valid which are to be observed for manual techniques in hammering and straightening.

Especially, the following key points should be observed:

- Use only proper hammers – the hammer shaft must be tightly wedged with the hammer head.
- Select the correct striking plate with regard to the form of bending – a hard and inflexible surface is required.
- Workpieces to be camped have to be tightly fixed in the clamping fixture so that they are not torn away by the striking impact
- Always strike against the fixed vise jaw so that the vise screw will not be damaged.
- Mind your hands and head when working on presses.
- Work with welding torches must not be performed until the instructor has given the necessary instructions.
- Always observe fire protection – place ready water for fire fighting, do not work close to inflammable materials.
- Only bend sheet metals and sections over 8 to 10 mm thickness and pipes of more than ½" in a heated state.

- Use only dry sand as filler for hot bending of pipes to avoid steam formation.

Knowing about these hints is to be confirmed by the trainees' signing in the control book.

### **2.3. Providing the Teaching Aids**

- The "Trainees' Handbook of Lessons – Bending" is to be distributed among the trainees according to their number.
- Illustrations contained in the "Trainees' Handbook of Lessons" and having a high indicative value should be used as visual aids (e.g. on flip charts, blackboards etc.)
- Workpieces showing well and badly performed bendings may be provided as visual objects.
- Particular tools and appliances not yet known to the trainees should also be used as visual illustrations, the same applies to brochures and photos of bending machines.
- If transparencies on bending are available, they should, in any case, be included in the instruction.

### **2.4. Providing the Working Means**

- The "Instruction Examples for Practical Vocational Training – Bending" as theoretical basis for the practical exercises to be performed should be distributed according to the number of trainees.
- The basic material required for the exercises should be prepared and provided with the help of the specification of materials given in the "Instruction Examples ....." in sufficient quantity.
- The workshop should be checked whether or not it is completely equipped with tools, appliances, machines, measuring and testing means as well as auxiliary means as to the exercises planned.
- Recommended basic outfit:
  - Steel rule, steel square, vernier caliper
  - Steel scribe, centre punch
  - Smooth files, band hack saw, hand-lever shear
  - Machinists' hammer, light metal hammer, special hammers for sheet metal working
  - Straightening plate, surface plate, vise
  - Various intermediate plates and bending mandrels
  - Drills and counterbores
  - Hand screw press, bending devices, folding bench, rolling device
  - Welding torch, dry sand
- Machines to be employed for bending have to be checked as to their serviceability with regard to labour safety before starting the exercises.
- For necessary drilling and counterboring operations, a table-type or column-type drilling machine with appurtenant clamping fixtures is required.
- Check serviceability of this machine prior to the practical exercises with regard to labour safety.

## **3. Recommendations for Implementing Vocational Training in Bending Techniques**

The following sections contain proposals on how to arrange the trainees' instruction, the demonstration of techniques as well as exercises and controls.

### **3.1. Introductory Instruction**

The introductory instruction should be given, if possible, with the trainees in a classroom. Attention is to be paid during the instruction to the trainees' noting down necessary additions or replies to questions in the "Trainees' Handbook of Lessons". An essential prerequisite for learning the bending techniques is the trainees' mastering the techniques in testing and hammering. This knowledge should be repeated, if necessary.

For your instruction you can use the "Trainees' Handbook of Lessons" with the following focal points:

#### ***Purpose of bending***

Initially, it would be favourable to explain to the trainees the purpose of bending with the help of visual objects and illustrations. In this connection, it must be made clear that bending is, due to its versatility, used in many fields of manufacture and performed by various techniques. Predominantly, the techniques in folding, turning over, flanging, seaming, rounding and rolling should be discussed.

#### ***Selected tools, appliances and machines***

Out of the variety of applicable working means it is recommendable to introduce or repeat the following:

- Hammer
- Welding torches
- Angle bending appliances, strip rolling devices, pipe benders
- Screw presses
- Folding bench, rounding device, crimping and flanging machine
- Vise, blacksmith's anvil

These working means may also be dealt with in a question–answer talk with the trainees, as far as the trainees have previous knowledge. Already here, particular characteristic features in their application can be stressed. If tools cannot be shown, the trainees should have a look at the illustrations in the "Trainees' Handbook of Lessons".

#### ***Processes in the material***

During this instruction section, the tensile and compressive stresses and their effects occurring during the bending process are to be discussed. The terms "stretching and upsetting" as well as "neutral axis" have to be explained.

In this connection, it is recommended to show the stretching and upsetting zone on a spot of rupture of a square section strongly bent. It is also favourable to make a blackboard drawing as to Fig. 14 of the "Trainees' Handbook of Lessons" to show the neutral axis. Subsequently, the influences of such material properties like "plasticity", "elasticity", "strength" and "strain hardening" are to be explained.

The trainees should keep in mind the knowledge so acquired in the form of rules and key sentences. To deepen the knowledge, the trainees have now to answer the questions asked in the "Handbook of Lessons" following the respective section.

In supplement of the influence data depicted just now, the influences of the bending radius, particularly the minimum bending radius, and the influences of heat reaction for the quality of bending can be discussed.

It is recommendable to put side by side a hot bent and a cold bent square section of 16 × 16. The trainees are to state the differences in quality of bending and derive from it the findings for their own work.

#### ***Fundamentals of calculation***

Comprehensively dealing with this focus is essential. The trainees are to be explained the necessity of the exact blank of the basic material. As for calculating the blank size, the straight length in dependence of the neutral axis position must be ascertained first.

The formulae required for it are distinctly introduced in the "Trainees' Handbook of Lessons".



With an example of application it is demonstrated that the blank length can be calculated out of a sum of different partial lengths. Here, the trainees should develop more examples for calculation to be solved by them without assistance, if possible.

### ***Bending techniques***

The techniques depending on material thickness and form of bending edge, as mentioned in the beginning, are described in the "Trainees' Handbook of Lessons", in principal.

Versions for each technique are shown, describing the manual making of bends with hammers or with mechanical devices as well as machines. It is not recommendable to describe the techniques all together during the lessons, what is more, it is favourable first to only explain the bending procedures which can be practised in the workshop with the help of existing working means.

That means that following the description of folding sheets practical exercises should be done, applying immediately in practice the knowledge just imparted.

Subsequently, the following techniques will be dealt with in the same way. It would be better, in case of slow learners or those having only a small previous knowledge, to impart the know-how in small, closely restricted sections and then support it with respective practical exercises.

### ***Hints on Labour safety***

Give the essential hints at the respective place, when bending procedures to be performed are described. These recommendations are contained in the text and as a compilation in the "Trainees' Handbook of Lessons".

## **3.2. Practical Exercises**

Basically, the necessary hints on labour safety have to be given prior to the practical exercises. Then, the trainees receive their working places and the technical equipment of the workshop is checked as to its serviceability. It is recommended to start any exercise with a demonstration in connection with the teacher's instruction related to the instruction example. Here, the trainees are to be motivated to perform the exercises in good quality. Difficulties to be expected have to be pointed out and evaluation key assessment should be mentioned at the same time.

It is necessary for the instructor to have previously performed the exercise himself.  
Only in such a way does he know the difficulties that may arise during its execution.

The course of exercise may be in change of instructions on the special techniques and the appurtenant exercises. With the help of "Instruction Examples for Practical Vocational Training – Bending", 6 practical exercises can be done by applying different techniques.

For that purpose, the "Instruction Examples....." contain a material list (base material, tools, appliances, measuring and testing instruments as well as auxiliary means), the sequence of operations to carry out the practical exercises and an illustrative working drawing. The trainees receive all the required information in it to be able to perform the exercises purposefully.

To give a survey, to which practical pieces the knowledge previously imparted is to be applied, the following individual instruction examples are briefly described.

Instruction examples:

### **Instruction example 14.1.: Mounting angle**

Sheet metals of 1 mm and 2 mm thick steel are to be folded in the vise. For that purpose, a sheet with a simple bending edge is to be bent manually.

A second sheet shall receive two bending edges by means of machinist's hammer and intermediate plate'

(Figure 1)

**Instruction example 14.2.: Half-round bracket**

A sheet steel strip is to be folded and rounded off in the vise with the help of a bending mandrel so that a serviceable half-round bracket is the result. Before bending, the straight length is to be calculated.

(Figure 2)

**Instruction example 14.3.: Hasp**

During this exercise, a sheet steel is to be rolled on a rolling device as well as round sections to be folded and bent to a round object by means of bending mandrels, so that a serviceable hasp will be the result after assembly.

(Figure 3)

**Instruction example 14.4.: Double pipe knee**

A steel pipe is to be rounded off twice with a bending device as well as with a machinist's hammer in the vise. In this case, sand filler and local heating are to be applied to. The heating length has to be calculated before.

**Instruction example 14.5.: Beaker jacket** (Figure 4)

A thin sheet steel is to be folded with the folding press, turned over and rounded off. Subsequently, a jacket seam joint is fabricated.

(Figure 5)

**Instruction example 14.6.: Beaker**

The previously fabricated beaker jacket is further worked on. After flanging, a bottom piece is connected with the beaker jacket by a bottom seam joint.

(Figure 6)

All trainees can do the exercises at the same time so far as material and equipment are available in sufficient quantity and number.

In this case, the trainees are able to perform any single exercise individually – each trainee should have as much time as needed.

If there are not enough working means, the trainees must be split into groups. Here it is favourable to divide them into groups according to the application of different tools and appliances.

As versions for the exercises to be done, the bendings can be made with various working means as well. In such a way, foldings should not only be made on the vise, but also on the folding press and folding bench. Even so should roundings not only be exercised manually, but also on the rounding-off device, if available.

Should the proposed instruction examples not be used for exercises, it would be possible to select other practising pieces. In this case, attention is to be paid to the fact that all the techniques previously discussed can be practised on these pieces as well.

***Focal points for practical execution***

It is recommended for the to fix certain criteria for the assessment of the exercises.

These could be the following:

- Do the trainees prepare their working places carefully?
- Is the straight length of workpiece exactly calculated?
- Is the basic material exactly cut to size?
- Are the appropriate working means selected and properly operated?
- Are the workpieces tightly clamped?
- Do the workpieces receive the required form and accuracy to size?
- Are workpieces damaged by improper work?
- Are the trainees able to assess the quality of their work themselves correctly?
- Do the trainees adhere to the labour safety regulations?

### 3.3. Questions for Recapitulation

To strengthen and check the knowledge and abilities so acquired, the following tasks have been made out in this section and are also contained in the "Trainees' Handbook of Lessons":

1) What is the purpose of bending?

*(To remodel workpieces that must have angular or rounded shapes for a specified purpose of application.)*

2) Which techniques are used for bending of sheet metals?

*(Folding, turning over, flanging, seaming, crimping, rounding, rolling.)*

3) What does the term "neutral axis" mean?

*(Transition zone in the bent workpiece where no tensile and compressive stresses occur.)*

4) Which material properties must parts to be bent not have?

*(They must not be brittle or spring-tempered.)*

5) What does the term "spring-back" (elastic recovery) mean?

*(Elastic materials spring back after an action of force by a certain measure.)*

6) What will happen when a sheet metal is being bent around a bending edge that is in accordance with the streak flow of rolling direction?

*(Cracks may occur on the bending's outer edge.)*

7) What does the term "strain hardening" mean?

*(When tensile and compressive stresses change for several times, the internal stresses grow and result in hardening at the bending point.)*

8) Which influence has the bending radius on developing cracks in the workpiece?

*(The larger the bending radius, the smaller the risk of cracks.)*

9) Which influence has workpiece thickness on bending radius?

*(The thicker the workpiece, the larger the bending radius must be.)*

10) Which influence has the material heating on the bending procedure in case of thick workpieces?

*(With growing heat, the internal resistance within the material decreases, the bending procedure becomes easier and is without risk of crack formation.)*

11) What does the term "stretched length" mean?

*(Length of workpiece before being bent: is calculated from the neutral axis length.)*

12) How does the position of the neutral axis change when workpieces are bent around a radius that is smaller than five times the workpiece thickness?

*(It shifts to the internal side of the bending.)*

13) How is the stretched length of a workpiece calculated, if several different bendings have to be effected?

*(Each bending is calculated individually as a partial length, then the partial lengths are summarized.)*

14) To which side have you to hammer when a sheet metal is to be folded on the vise?

*(Towards the side of fixed jaw.)*

15) Which side of the workpiece has to be scribed with the steel scriber?

*(On the bending's internal side.)*

16) From which sheet thickness onwards should workpieces be hot-bent?

*(From 8 mm sheet thickness onwards.)*

17) What is the significance of hardwood or metal intermediate plates for bending on the vise?

*(They serve to compensate distances when workpieces with several bending edges are to be folded. They also absorb the impact when you strike with a machinist's hammer.)*

18) How are sheets with long bending edges clamped in the vise?

*(With sheet clamp or angular sections, both being additionally fixed with a ferrule.)*

19) What is to be done before sections are folded?

*(Prior to bending, the upsetting zone is to be separated.)*

20) How are sheet metals to be turned over?

*(They are folded by 90° and turned over with presses or hammers to a bending angle of up to 180°.)*

21) How is a sheet metal cylinder flanged manually?

*(Slightly flange with the hammer pane (striking face of a hammer) on the bordering tool and finish flanging with the hammer face on a plane striking plate.)*

22) By which working steps is seaming marked?

*(Turning over with shims, hooking-in, pressing together.)*

23) What does "crimping" mean?

*(Producing curl-like recesses in sheets to stiffen the metal)*

24) How can sheet metals be rounded off in a vise?

*(Clamp the sheet with the bending form and turn it overstep by step with the hammer.)*

25) With which appliances can sections be rounded off?

*(With bending devices, bending dies, section bending machines, swage block.)*

26) What is to be noted when pipes of over 1/2" in diameter are rounded off?

*(Pipe must be filled with sand prior to being bent.)*

28) What is to be noted when welded pipes are rounded off?

*(Welding seam must be lateral to bending radius in neutral axis.)*

29) Which length has to be exactly calculated prior to hot-bending?

*(The bend length to be heated.)*

30) How is the bend length scribed?

*(From the dimension length, the dimension leg is scribed to one side on the unbent pipe and the bending leg to the other side.)*

31) How may sheet rims be rolled?

*(With hammers on round sections, with devices or presses.)*

32) How may springs be wound?

*(Mechanically with lathes or manually with winding mandrels and wood clamp in the vise.)*

