



## Preheating temperature

The temperature of the tool during the entire welding process should be maintained at 200–350°C (390–480°F). This is best achieved using electrical heating elements. If the tool is preheated in a furnace prior to welding, then it is important that the furnace temperature is below 175°C (350°F) when the tool is put in.

Small repairs can be made by TIG welding at room temperature. Max. interpass temperature 375°C (705°F).

When welding with MMA preheating is recommended.

## Building up the weld

The root runs should be made with a small-diameter electrode ( $\varnothing$  max 3.25 mm). If TIG welding, the current should be limited to 120 A.

The first two runs should always be welded with the same low heat input, while a greater heat input can be used for the remaining layers.

Ensure that the heat from each run tempers the previous run. Hence even for very minor repairs, the minimum number of runs should be two.

Use a short arc and weld in separate runs. Do not oscillate the gun. Angle the electrode 90° to the joint sides in order to avoid undercut. In addition, the electrode should be held at an angle of 75–85° to the direction of forward movement.

For small repairs and for the final runs along the fusion line, TIG welding is to be preferred. The transition region between weld and base steel should be carefully inspected prior to finishing welding. Arcing sores or undercut should be repaired while the tool is still hot. After welding, the final layer of weld metal is ground away prior to any further treatment.

If the tool is to be polished or photo-etched TIG welding is to be preferred, so that pores, arcing sores or undercut can be avoided.

## Treatment after welding

The tool should cool slowly the first two hours 20–40°C/h (35–70°F/h), then freely in air.

For large weld repairs a stress-relieving is recommended at 550°C (1020°F) during 2 h.

If the tool is to be polished or photo-etched following heat treatment is recommended:

*Polishing:* tempering temperature 550°C x 2 h (1020°F x 2 h).

*Photo-etching:* tempering temperature 610°C x 2 h (1130°F x 2 h).

For more detailed information, ask your Uddeholm representative for the brochure “Welding of Tool Steel”.



Uddeholm Impax Supreme welded with a dissimilar filler rod.



Uddeholm Impax Supreme welded with a filler rod of matching composition.

### FURTHER INFORMATION

Please contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels. For more information, please visit [www.uddeholm.com](http://www.uddeholm.com) or [www.assab.com](http://www.assab.com)

U  
S  
P  
L  
I  
E  
R  
O  
F  
T  
O  
O  
L  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
R  
E  
S  
U  
L  
T  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
T  
O  
O  
L  
S  
T  
O  
T  
A  
L  
E  
C  
O  
N  
O  
M  
Y  
E  
R  
Y  
D  
A  
Y  
N  
E  
T  
W  
O  
R  
K  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
S  
T  
O  
T  
A  
L  
E  
C  
O  
N  
O  
M  
Y  
H  
I  
G  
H  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
A  
R  
T  
I  
C  
L  
E  
S  
H  
I  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
R  
E  
S  
I  
S  
T  
A  
N  
C  
E  
M  
A  
C  
H  
I  
N  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
H  
I  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
P  
A  
R  
T  
N  
E  
R  
S  
H  
I  
P  
S  
T  
A  
N  
D  
I  
N  
G  
M  
A  
C  
H  
I  
N  
I  
N  
G  
S  
O  
M  
E  
T  
H  
I  
N  
G  
R  
U  
S  
T  
I  
S  
S  
O  
M  
E  
T  
H  
I  
N  
G  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
A  
N  
D  
L  
E  
A  
D  
I  
N  
G  
S  
U  
P  
P  
L  
I  
E  
R  
O  
F  
T  
O  
O  
L  
I  
N  
G  
B  
U  
S  
I  
N  
E  
S  
S  
S  
T  
R  
E  
N  
G  
T  
H  
I  
N  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
P  
A  
R  
T  
N  
E  
R  
S  
H  
I  
P  
S  
T  
A  
N  
D  
I  
N  
G  
M  
A  
C  
H  
I  
N  
I  
N  
G  
L  
E  
A  
D  
I  
N  
G  
S  
U  
P  
P  
L  
I  
E  
R  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
E  
C  
O  
N  
O  
M  
Y  
T  
H  
E  
W  
O  
R  
L  
D  
T  
O  
T  
A  
L  
E  
C  
O  
N  
O  
M  
Y  
T  
O  
U  
G  
H  
N  
E  
S  
S  
T  
R  
E  
N  
G  
T  
H  
I  
N  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
T  
O  
U  
G  
H  
N  
E  
S  
S  
I  
N  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
E  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A  
L  
S  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
K  
N  
O  
W  
L  
E  
D  
G  
E  
U  
N  
D  
E  
R  
S  
T  
A  
N  
D  
I  
N  
G  
P  
R  
E  
S  
E  
N  
C  
E  
L  
O  
N  
G  
D  
U  
R  
A  
B  
I  
L  
I  
T  
Y  
A  
R  
N  
E  
V  
E  
R  
Y  
D  
A  
Y  
L  
O  
N  
G  
L  
A  
S  
T  
I  
N  
G  
S  
O  
L  
V  
I  
N  
G  
P  
R  
O  
B  
L  
E  
M  
S  
A  
U  
T  
O  
M  
O  
T  
I  
V  
E  
T  
O  
O  
L  
I  
N  
G  
L  
A  
S  
T  
I  
N  
G  
T  
O  
O  
L  
I  
N  
G  
P  
E  
R  
F  
O  
R  
M  
A  
N  
C  
E  
D  
U  
C  
T  
I  
L  
I  
T  
Y  
O  
F  
T  
O  
O  
L  
I  
N  
G  
M  
A  
T  
E  
R  
I  
A