

FUNDAMENTAL MANUFACTURING PROCESSES

Brazing & Soldering

SCENE 1.

CG: FBI warning
white text centered on black to
blue gradient

WARNING

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criminal penalties for the unauthorized
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of copyrighted videotapes.

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Society of Manufacturing Engineers

SCENE 2.

CG: SME disclaimer
white text centered on black to
blue gradient

Always read the operating manual and safety
information provided by the manufacturer before
operating any brazing & soldering equipment.
Make sure all machine guards are in place, and
follow all safety procedures when working with or
near brazing & soldering equipment.

SCENE 3.

CG: AFFT screen A
white text centered on black to
blue gradient
03A, GRAPHIC: AFFT logo

This program was produced using the technical
resources of the Association for Forming &
Fabricating Technologies of the Society of
Manufacturing Engineers.

SCENE 4.

continue AFFT logo graphic
CG: AFFT screen B
white text centered on black to
blue gradient

For more information on brazing & soldering,
please visit our website at:
www.sme.org/afft

SCENE 5.

05A, tape 40, 01:00:00-01:00:12
SME logo, with music
CG, SUPER: www.sme.org

SCENE 6.

06A, tape 25, 01:01:00-01:01:45
FMP open, with music
06B, peter carey narration

MUSIC UP AND UNDER

NARRATION (VO):

THE FUNDAMENTAL MANUFACTURING PROCESSES VIDEO
SERIES, EXAMINING THE TOOLS AND TECHNIQUES OF
PRECISION MANUFACTURING.

SCENE 7.

program title:
CG: Brazing & Soldering
white text centered on black

NARRATION (VO) :

THIS PROGRAM EXPLORES THE FUNDAMENTALS OF BRAZING
AND SOLDERING.

SCENE 8.

08A, tape 853, 11:22:18-11:22:28
brazing operation
08B, tape 848, 04:15:45-04:16:13
circuit board soldering
operation
08C, tape 847, 03:06:38-03:06:53
zoom in, circuit board

NARRATION (VO) :

BRAZING...,
AND SOLDERING ARE JOINING PROCESSES THAT USE HEAT,
FILLER METAL,
AND USUALLY FLUX TO PRODUCE A METALLURGICAL BOND
BETWEEN MATERIALS.

SCENE 9.

09A, tape 857, 16:22:13-16:22:29
zoom out, furnace brazing
operation
09B, tape 854, 12:25:06-12:25:26
zoom out, soldering operation
09C, tape 851, 08:25:31-08:25:52
zoom in, induction brazing
operation
09D, tape 847, 03:14:10-03:14:27
torch soldering operation

NARRATION (VO) :

BRAZING...,
AND SOLDERING ARE SIMILAR IN PROCESS, WITH THE
MAIN DIFFERENCE BEING THAT BRAZING IS PERFORMED
USING A FILLER METAL HAVING A MELTING, OR
LIQUIDOUS, TEMPERATURE 'ABOVE' 840 DEGREES
FAHRENHEIT, OR 450 DEGREES CELSIUS, WHILE THE
FILLER METALS USED IN SOLDERING HAVE LIQUIDOUS
TEMPERATURES 'BELOW' 840 DEGREES FAHRENHEIT, OR
450 DEGREES CELSIUS.

SCENE 10.

10A, tape 852, 09:03:32-09:03:52
zoom out, brazing operation
10B, tape 854, 12:14:41-12:14:58
zoom out, joints finished on
brazed workpiece

NARRATION (VO) :

BOTH BRAZING,
AND SOLDERING OPERATIONS ARE PERFORMED AT
TEMPERATURES BELOW THE MELTING, OR SOLIDUS,
TEMPERATURE OF THE BASE MATERIALS BEING JOINED.
FOR THIS REASON, PROPERTIES OF BRAZED AND SOLDERED
JOINTS ARE TYPICALLY NOT THE SAME AS THOSE OF THE
BASE METAL.

SCENE 11.

11A, tape 808, 08:11:16-08:11:30

c.u., zoom out, filler metal added to brazing operation

NARRATION (VO) :

THE FILLER METALS FOR BOTH BRAZING AND SOLDERING ARE TYPICALLY HELD IN, OR DISTRIBUTED BETWEEN CLOSELY FITTED, INTERFACING, OR FAYING, JOINT SURFACES BY CAPILLARY ACTION.

SCENE 12.

12A, tape 860, 19:15:44-19:16:04

c.u. filler metal added to brazing operation

12B, ANI: liquefied filler metal drawn into joint between two parallel surfaces through capillary action

12C, GRAPHIC: last frame of animation, cooled down

NARRATION (VO) :

CAPILLARY ACTION OCCURS BECAUSE THE ATOMS OF THE LIQUEFIED FILLER METAL HAVE STRONGER ATTRACTION TO THE BASE METALS' ATOMS THAN TO THEIR OWN. WHEN THIS ATTRACTION OCCURS BETWEEN TWO SURFACES, THE LIQUID EVENLY DISTRIBUTES ITSELF.

SCENE 13.

13A, tape 861, 20:07:07-20:07:24

zoom out, torch brazing operation

NARRATION (VO) :

THE SPREADING OF A LIQUID THROUGH CAPILLARY ACTION AND ADHERING IN A CONTINUOUS LAYER TO A SOLID MATERIAL IS COMMONLY REFERRED TO AS WETTING.

SCENE 14.

14A, tape 860, 19:11:39-19:12:00

fluxing part components

14B, tape 860, 19:08:40-19:09:00

fluxed part brazed

NARRATION (VO) :

IN MANY CASES, FLUX IS USED TO ASSIST IN THE PROPER DISTRIBUTION OF FILLER METAL. THE PRIMARY PURPOSE OF FLUX IS TO INHIBIT THE FORMATION OF OXIDES AND OTHER UNDESIRABLE MATERIALS WITHIN THE MOLTEN FILLER METAL AND ON JOINT SURFACES DURING JOINING.

SCENE 15.

15A, tape 854, 12:22:52-12:23:08

c.u. flux applied to joint

15B, tape 854, 12:24:36-12:24:41

filler metal in joint being brazed, slow down shot if necessary

NARRATION (VO) :

FLUX ALSO PROMOTES WETTING JOINT SURFACES BY LOWERING SURFACE TENSION DURING JOINING. FLUX HAS A LOWER ATTRACTION TO THE BASE METALS' ATOMS THAN DOES THE FILLER METAL. AS THE FILLER METAL MELTS,

IT PUSHES OUT THE MAJORITY OF THE MOLTEN FLUX AND
ADHERES TO A CLEAN, OXIDE-FREE SURFACE.

SCENE 16.

16A, tape 855, 13:02:36-13:02:48
removal of flux in acid bath
after joining
16B, tape 861, 20:17:30-20:17:55
mechanical cleaning of flux
residue

NARRATION (VO) :

FLUX RESIDUE IS CORROSIVE, SO ITS REMOVAL AFTER
JOINING IS ESSENTIAL. SOAKING IN HOT OR WARM WATER
IS A COMMON PROCEDURE, BUT MECHANICAL CLEANING MAY
SOMETIMES BE NECESSARY.

SCENE 17.

17A, tape 808, 08:10:42-08:10:50
wide, brazing operation
17B, tape 377, 00:15:02-00:15:08
automobile being manufactured
17C, tape 483, 11:04:08-11:04:20
aircraft taking off
17D, tape 600, 06:25:30-06:25:43
appliance being manufactured
17E, tape 808, 08:03:23-08:03:32
tubes being soldered
17F, tape 848, 04:12:28-04:12:36
wave soldering of electronics

NARRATION (VO) :

BRAZING AND SOLDERING OPERATIONS ARE USED FOR MANY
INDUSTRIAL APPLICATIONS, INCLUDING MANUFACTURING
AUTOMOBILES...,
AIRCRAFT...,
APPLIANCES...,
TUBE AND PIPE...,
AND ELECTRONICS.

SCENE 18.

18A, tape 808, 08:08:01-08:08:12
zoom out, soldering pipes
18B, GRAPHIC: lap joint
CG, SUPER: Lap Joint
18C, GRAPHIC: flanged lap joint
CG, SUPER: Flanged Lap Joint
18D, GRAPHIC: butt joint
CG, SUPER: Butt Joint
18E, GRAPHIC: flanged butt joint
CG, SUPER: Flanged Butt Joint

NARRATION (VO) :

AN IMPORTANT ASPECT OF BOTH BRAZING AND SOLDERING
IS JOINT DESIGN, WITH THE PRIMARY JOINT TYPES USED
INCLUDING:
THE LAP JOINT...,
THE FLANGED LAP JOINT...,
THE BUTT JOINT...,
AND THE FLANGED BUTT JOINT.

SCENE 19.

19A, tape 847, 03:17:28-03:17:46
joints being prep for soldering
19B, tape 851, 08:12:05-08:12:30
joints being prep for brazing

NARRATION (VO) :

JOINT PREPARATION IS ESSENTIAL IN BRAZING AND
SOLDERING. ALL DIRT, GREASE AND PAINT MUST BE
REMOVED FROM JOINT SURFACES PRIOR TO JOINING TO

ENSURE FULL CAPILLARY ACTION OF FLUX AND FILLER METAL. JOINT SURFACES ARE TYPICALLY CLEANED USING CHEMICAL OR MECHANICAL METHODS.

SCENE 20.

20A, tape 850, 07:27:08-07:27:32
chemical cleaning of braze components

CG, SUPER: Petrochemical Solvents
Alkaline Cleaning Agents
Electrolytic Cleaning
Salt Baths

NARRATION (VO) :

CHEMICAL CLEANING METHODS INCLUDE THE USE OF PETROCHEMICAL SOLVENTS,
ALKALINE CLEANING AGENTS,
ELECTROLYTIC CLEANING,
AND SALT BATHS.

SCENE 21.

21A, tape 851, 08:10:07-08:10:34
zoom out, mechanical cleaning of soldering components

CG, SUPER: Grinding
Machining
Sanding
Wire Brushing
Blasting

NARRATION (VO) :

MECHANICAL METHODS OF CLEANING JOINT SURFACES INCLUDE:
GRINDING,
MACHINING,
SANDING,
WIRE BRUSHING,
AND BLASTING.

SCENE 22.

22A, tape 856, 15:08:43-15:09:01
zoom out, assemblies prepared for furnace brazing

22B, tape 846, 02:07:06-02:07:18
zoom out, wave soldering operation

NARRATION (VO) :

ONCE CLEANED, ASSEMBLIES ARE PREPARED FOR JOINING USING EITHER BRAZING...,
OR SOLDERING PROCESSES.

--- FADE TO BLACK ---

SCENE 23.

CG: Brazing & Brazing Processes
white text centered on black

SCENE 24.

24A, peter carey narration
24B, tape 857, 16:03:46-16:04:20
zoom out, furnace brazing operation

NARRATION (VO) :

BRAZING IS OFTEN SELECTED OVER OTHER JOINING

24C, tape 855, 14:04:02-14:04:29 METHODS SUCH AS MECHANICAL FASTENING, AND WELDING
dissimilar materials being FOR MANY REASONS, SUCH AS:
readied for brazing
CG, ROLL: Inaccessible Joint INACCESSIBLE JOINT AREAS THAT CANNOT BE JOINED
Areas That Cannot Be USING WELDING PROCESSES CAN BE JOINED USING
Joined Using Welding BRAZING,
Processes Can Be THIN-WALL TUBES AND ASSEMBLIES DAMAGEABLE BY
Joined Using Brazing WELDING CAN BE JOINED BY BRAZING,
Thin-Wall Tubes & MULTIPLE JOINTS CAN BE BRAZED AT ONE TIME, AND THE
Assemblies Damageable PROCESS IS READILY AUTOMATED FOR HIGH PRODUCTION
By Welding Can Be RATES,
Joined By Brazing BRAZED JOINTS CAN BE DUCTILE AND CORROSION
Multiple Joints Can Be RESISTANT,
Brazed At One Time, & AND BRAZING CAN JOIN DISSIMILAR METALS AND NON-
The Process Is METALLIC MATERIALS.
Readily Automated For
High Production Rates
Brazed Joints Can Be
Ductile & Corrosion
Resistant
Brazing Can Join
Dissimilar Metals &
Non-Metallic
Materials

SCENE 25.

25A, tape 858, 17:16:01-17:16:32 NARRATION (VO) :
zoom out, ferrous metal MOST FERROUS AND NONFERROUS METALS, PLUS CARBIDES,
components conveyed into brazing SUCH AS TUNGSTEN CARBIDES, AND CERMETS CAN BE
furnace BRAZED. BRAZABLE FERROUS METALS INCLUDE:
CG, SUPER: Plain Carbon Steels PLAIN CARBON STEELS,
Low- & High-Alloy LOW-AND HIGH-ALLOY STEELS,
Steels STAINLESS STEELS,
Stainless Steels AND MOST CAST IRONS.
Most Cast Irons BRAZABLE NONFERROUS METALS INCLUDE:
25B, tape 852, 09:07:31-09:08:01 ALUMINUM,
zoom out, nonferrous metal ready COPPER,
for brazing BRONZE,
CG, SUPER: Aluminum BRASS,
Copper NICKEL,
Copper TITANIUM,
Bronze
Brass
Nickel
Titanium

TITANIUM AND THEIR ALLOYS.

SCENE 26.

26A, tape 861, 20:01:05-20:01:38

fluxed part being brazed

CG, SUPER: Fluorides

Chlorides

Borax

Borates

Fluoroborates

Alkalis

Wetting Agents

Water

NARRATION (VO) :

FLUXES FOR BRAZING TYPICALLY CONTAIN FLUORIDES,

CHLORIDES,

BORAX,

BORATES,

FLUOROBORATES,

ALKALIS,

WETTING AGENTS,

AND WATER.

SCENE 27.

continue previous shot

27A, tape 849, 06:03:12-06:03:20

liquid flux

27B, tape 849, 06:05:06-06:05:13

paste flux

27C, tape 849, 06:10:25-06:10:33

zoom out, powder flux

NARRATION (VO) :

FLUXES ARE AVAILABLE IN MANY FORMS INCLUDING:

LIQUIDS...,

PASTES...,

POWDERS,

AND PREFORMS.

SCENE 28.

28A, tape 861, 20:12:34-20:12:50

flux brushed on assembly

CG, SUPER: Brushing

Spraying

Dipping

NARRATION (VO) :

VARIOUS METHODS ARE USED TO APPLY BRAZING FLUX TO

THE JOINT, WITH THE MOST COMMON BEING BRUSHING,

SPRAYING,

OR DIPPING.

SCENE 29.

29A, tape 860, 19:18:56-19:19:06

zoom out, induction brazing with fumes being captured

NARRATION (VO) :

FLUXES, WHEN HEATED, CAN BE TOXIC IF INHALED, SO

PROPER SAFETY PRECAUTIONS MUST BE TAKEN DURING

THEIR USE.

SCENE 30.

30A, tape 856, 15:27:39-15:27:48

zoom in, filler metal added to joint

NARRATION (VO) :

THE TYPE OF FILLER METAL USED FOR BRAZING DEPENDS

30B, tape 850, 07:19:10-07:19:38 ON THE BASE METAL OR MATERIALS BEING JOINED. THE
zoom out, filler metal added to MOST COMMON FILLER METALS INCLUDE:
joint
CG, SUPER: Aluminum-Silicon
Copper ALUMINUM-SILICON,
Copper-Phosphorus COPPER,
Magnesium COPPER-PHOSPHORUS,
Silver MAGNESIUM,
Nickel Alloys SILVER,
AND NICKEL ALLOYS.

SCENE 31.

31A, tape 860, 19:01:50-19:02:13 NARRATION (VO) :
wire filler metal applied to FILLER METALS EACH FLOW WITHIN SPECIFIC
joint TEMPERATURE RANGES AND ARE AVAILABLE IN MANY
31B, tape 849, 06:09:44-06:09:55 FILLER METALS EACH FLOW WITHIN SPECIFIC
filler metal foil FORMS, INCLUDING:
31C, tape 851, 08:19:57-08:20:05 WIRE...,
filler metal paste FOIL...,
31D, tape 859, 18:07:40-18:07:50 PASTE...,
filler metal powder POWDER...,
31E, tape 849, 06:07:30-06:07:38 AND PREFORMS.
filler metal preform

SCENE 32.

32A, tape 860, 19:02:46-19:03:16 NARRATION (VO) :
zoom out, brazing operation FILLER METALS COMMONLY HAVE A SIGNIFICANTLY
DIFFERENT COMPOSITION THAN THE METALS BEING
JOINED. PROPER FILLER METAL SELECTION IS IMPORTANT
TO AVOID PROBLEMS SUCH AS GALVANIC CORROSION OR
FORMATION OF BRITTLE INTER-METALLIC COMPOUNDS
WITHIN THE JOINT.

SCENE 33.

continue previous shot
33A, GRAPHIC: parts with TYPICAL BRAZING JOINT CLEARANCES FOR GOOD
clearance
33B, GRAPHIC: c.u. joint area
33C, GRAPHIC: c.u. joint area, double-sided arrow indicating
CAPILLARY FLOW AND JOINT STRENGTH RANGE FROM ONE

joint clearance
CG, SUPER: 0.001 Of An Inch/
0.025 Of A
Millimeter To 0.005
Of An Inch/0.13 Of A
Millimeter

THOUSANDTH OF AN INCH, OR TWENTY FIVE THOUSANDTHS
OF A MILLIMETER, TO FIVE THOUSANDTHS OF AN INCH,
OR APPROXIMATELY THIRTEEN HUNDREDTHS OF A
MILLIMETER.

SCENE 34.

34A, tape 856, 15:04:32-15:04:45
torch brazing operation
CG, SUPER: Torch Brazing
34B, tape 859, 18:12:16-18:12:32
furnace brazing of assemblies
CG, SUPER: Furnace Brazing
34C, tape 852, 09:04:46-09:04:56
dip brazing operation
CG, SUPER: Dip Brazing
34D, tape 853, 11:05:56-11:06:05
zoom out, brazing operation
CG, SUPER: Induction Brazing

NARRATION (VO):

COMMON METHODS OF BRAZING, INCLUDE:
TORCH BRAZING...,
FURNACE BRAZING...,
DIP BRAZING...,
AND INDUCTION BRAZING.

SCENE 35.

CG, SUPER: Torch Brazing
CG, SUPER: Flame Brazing
35A, tape 861, 20:05:26-20:05:36
torch brazing operation

NARRATION (VO):

TORCH BRAZING, WHICH IS ALSO COMMONLY REFERRED TO
AS FLAME BRAZING, USES OXYFUEL GAS.

SCENE 36.

36A, tape 861, 20:12:54-20:13:07
flux applied to the joint before
torch heating
36B, tape 861, 20:11:23-20:11:53
c.u. brazing filler metal
deposited in the joint

NARRATION (VO):

FLUX IS TYPICALLY APPLIED TO THE JOINT BEFORE
HEATING...,
AND THE BRAZING FILLER METAL IS DEPOSITED AS SOON
AS THE JOINT IS UP TO TEMPERATURE, BUT THE FILLER
METAL CAN ALSO BE PLACED IN THE JOINT ALONG WITH
THE FLUX PRIOR TO HEATING.

SCENE 37.

continue previous shot

NARRATION (VO):

TORCH BRAZING IS PERFORMED MANUALLY, BUT CAN ALSO
BE AUTOMATED AS A PRODUCTION PROCESS.

--- TOUCH BLACK ---

SCENE 38.

CG, SUPER: Furnace Brazing
38A, tape 854, 12:26:44-12:26:57

NARRATION (VO):

assemblies coming out of brazing furnace

38B, tape 855, 13:06:49-13:06:55
assemblies for furnace brazing cleaned

38C, tape 850, 07:12:56-07:13:13
assemblies preloaded with filler metal

38D, tape 855, 14:08:56-14:09:28
assemblies fixtured for furnace brazing

FURNACE BRAZING IS THE MOST COMMONLY USED PRODUCTION BRAZING TECHNIQUE. AS THE NAME SUGGESTS, THE PROCESS IS CARRIED OUT IN A FURNACE, WITH ASSEMBLED COMPONENTS CLEANED..., PRELOADED WITH FILLER METAL IN, OR AT, THE JOINTS..., AND THEN FIXTURED FOR PROPER POSITIONING DURING BRAZING.

SCENE 39.

39A, tape 850, 07:03:58-07:04:08
batch furnace being opened

39B, tape 858, 17:03:51-17:04:00
zoom out, assemblies conveyed into furnace

NARRATION (VO) :

BOTH BATCH..., AND CONTINUOUS CONVEYOR FURNACES ARE USED FOR BRAZING.

SCENE 40.

40A, tape 852, 10:04:09-10:04:20
prepared assemblies are stacked on tray

40B, tape 852, 10:04:44-10:05:09
tray loaded into the furnace

40C, tape 852, 10:06:53-10:07:04
batch furnace closed, secured

NARRATION (VO) :

BATCH BRAZING OPERATIONS USE RETORTS OR COLD-WALL VACUUM FURNACES. PREPARED ASSEMBLIES ARE STACKED ON TRAYS..., LOADED INTO THE FURNACE..., AND THEN BROUGHT TO TEMPERATURE, BRAZING ALL ASSEMBLIES AT THE SAME TIME.

SCENE 41.

41A, tape 855, 14:17:40-14:17:54
assemblies coming out of batch furnace

NARRATION (VO) :

BATCH BRAZING FURNACES ARE COMMONLY USED TO JOIN ASSEMBLIES HAVING COMPLEX JOINT DESIGNS.

SCENE 42.

42A, tape 858, 17:07:43-17:08:06
zoom out, assemblies conveyed into furnace

NARRATION (VO) :

CONTINUOUS BRAZING USES A CONVEYOR BELT OR ROLLS TO TAKE THE ASSEMBLIES THROUGH THE BRAZING FURNACE.

SCENE 43.

continue previous shot

NARRATION (VO) :

THESE FURNACES HAVE MULTIPLE ZONES FOR PREHEATING
THE ASSEMBLIES...,
HIGH HEAT BRAZING...,
AND COOL-DOWN.

SCENE 44.

44A, tape 857, 16:11:50-16:12:03
assemblies conveying into
furnace

NARRATION (VO) :

CONTINUOUS CONVEYOR BRAZING IS USED FOR HIGH
PRODUCTION RUNS TYPICALLY ON SMALL PARTS WITH
SIMPLE JOINT DESIGNS.

SCENE 45.

45A, tape 858, 17:02:09-17:02:20
zoom out, furnace brazing using
furnace with special protective
atmosphere
45B, tape 855, 13:05:25-13:05:32
static, vacuum furnace

NARRATION (VO) :

FURNACE BRAZING IS MOST COMMONLY PERFORMED IN
FURNACES HAVING VARIOUS SPECIAL PROTECTIVE
ATMOSPHERES...,
OR IN VACUUM FURNACES.

SCENE 46.

46A, tape 855, 14:16:01-14:16:17
assemblies coming out of vacuum
furnace

NARRATION (VO) :

THE USE OF FURNACES WITH SPECIAL PROTECTIVE
ATMOSPHERES, OR VACUUM FURNACES ELIMINATES THE
NEED FOR FLUXING, PRECLUDING THE NEED TO REMOVE
FLUX RESIDUE AFTER JOINING.

SCENE 47.

47A, tape 857, 16:15:36-16:16:01
zoom out, assemblies coming out
of furnace

NARRATION (VO) :

PROTECTIVE ATMOSPHERES OR VACUUM FURNACES ARE ALSO
USED TO PREVENT OXIDE FORMATION OF REACTIVE,
REFRACTORY, OR HIGH-TEMPERATURE METALS, AND TO
CONTROL CARBON CONTENT, PREVENTING THE
DECARBURIZATION OF STEEL.

--- TOUCH BLACK ---

SCENE 48.

CG, SUPER: Dip Brazing
48A, tape 854, 12:05:13-12:05:25

NARRATION (VO) :

assembly dipped in molten
chemical bath

IN DIP BRAZING, ASSEMBLIES MAY BE DIPPED IN A
MOLTEN FILLER METAL BATH, BUT ARE MOST TYPICALLY
IMMERSED, HEATED AND BRAZED IN A MOLTEN CHEMICAL
BATH.

SCENE 49.

49A, tape 851, 08:16:36-08:16:52
zoom out, assemblies prepared
with filler metal

49B, tape 854, 12:01:29-12:01:47
prepared assemblies preheated

49C, tape 854, 12:07:24-12:08:00
prepared assemblies dipped in
molten chemical bath

NARRATION (VO) :

THE CLEANED ASSEMBLIES ARE PREPARED WITH FILLER
METAL PLACED IN THE JOINTS...,
THE ASSEMBLIES ARE THEN PREHEATED...,
AND THEN DIPPED IN THE MOLTEN CHEMICAL BATH WHICH
SERVES AS THE FLUX AND MELTS THE FILLER METAL.

SCENE 50.

continue previous shot

50A, tape 855, 14:10:17-14:10:28
zoom out, clamped assemblies
before dipping

NARRATION (VO) :

DIP BRAZING IS COMMONLY USED FOR DIPPING COMPLEX
ASSEMBLIES OF VARIOUS THICKNESSES, AND IS
PERFORMED AT TEMPERATURES CLOSE TO THE MELTING
POINT OF THE BASE METALS. FIXTURING THE ASSEMBLIES
IS IMPORTANT. ASSEMBLIES CAN BE SELF-FIXTURED BY
CRIMPING OR SWAGING, OR MECHANICALLY FIXTURED BY
USING HEAT-RESISTANT EXTERNAL SPRINGS AND CLAMPS.

SCENE 51.

51A, tape 854, 12:11:28-12:11:38
assemblies coming out of bath

51B, tape 854, 12:12:58-12:13:15
assemblies placed in washer

51C, tape 854, 12:17:54-12:18:06
zoom out, additional cleaning of
dipped assemblies

NARRATION (VO) :

ONCE THE ASSEMBLIES ARE RAISED FROM THE BATH...,
THEY ARE RINSED IN HOT WATER TO LOOSEN FLUX
RESIDUE...,
ASSEMBLIES THEN UNDERGO ADDITIONAL CLEANING STEPS
TO ENSURE COMPLETE FLUX-RESIDUE REMOVAL.

--- TOUCH BLACK ---

SCENE 52.

CG, SUPER: Induction Brazing

52A, tape 853, 11:19:11-11:19:30
zoom in, induction brazing

NARRATION (VO) :

INDUCTION BRAZING USES AN INDUCTOR COIL OR COILS

operation

TO INDUCE AN 'AC', OR ALTERNATING CURRENT, IN AN ASSEMBLY. AS THIS CURRENT FLOWS WITHIN AND AROUND THE ASSEMBLY, HEAT IS GENERATED FROM THE RESISTANCE OF THE ASSEMBLY TO THE CURRENT, BRINGING IT QUICKLY UP TO BRAZING TEMPERATURE.

SCENE 53.

53A, tape 853, 11:13:04-11:13:18

pan, inductor coils

53B, tape 853, 11:05:23-11:05:59

zoom in, inductor coils during induction brazing operation

NARRATION (VO) :

INDUCTOR COILS CAN BE MADE OF COPPER TUBING OR MACHINED FROM COPPER BLOCK, AND ARE SHAPED TO MAXIMIZE CURRENT TRANSFER TO THE ASSEMBLY BEING BRAZED. TO PREVENT MELTING, INDUCTOR COILS ARE COMMONLY WATER COOLED INTERNALLY.

SCENE 54.

continue previous shot

NARRATION (VO) :

COILS MUST BE CLOSELY COUPLED TO THE ASSEMBLIES BEING BRAZED, THE CLOSER THE COUPLING, OR GAP, THE MORE EFFICIENT THE OPERATION. THE GAP ALSO CAN BE USED TO CONTROL THE RATE OF HEATING OF DIFFERENT PARTS IN THE ASSEMBLIES.

--- FADE TO BLACK ---

SCENE 55.

CG: Soldering & Soldering

Processes

white text centered on black

SCENE 56.

56A, peter carey narration

56B, tape 845, 01:08:06-01:08:24

zoom in, iron soldering

NARRATION (VO) :

SOLDERING PROCESSES ARE SOME OF THE OLDEST METHODS USED TO JOIN METALS, WITH MOST PRODUCING AN INTER-METALLIC-TYPE METALLURGICAL BOND BETWEEN THE SOLDER AND BASE MATERIALS.

SCENE 57.

57A, tape 849, 05:08:14-05:08:46

NARRATION (VO) :

c.u. repairing soldered joint
57B, tape 847, 03:03:01-03:03:20
zoom in, circuit boards coming
out of wave soldering operation
CG, ROLL: Multiple, Reliable
 Joints Can Be Made
 Quickly &
 Economically,
 Evaluated Visually,
 & Easily Repaired If
 Necessary
The Low Temperatures
Employed For
Soldering Minimize
Distortion And Heat
Damage To The
Components Being
Joined
Dissimilar Materials,
Such As Ceramic-To-
Metal Or Glass-To-
Metal, May Be
Soldered
Soldering Processes
Are Easily Automated
For High Production

SOLDERING OFFERS MANY ADVANTAGES OVER OTHER
FASTENING PROCESSES, SUCH AS:
MULTIPLE, RELIABLE JOINTS CAN BE MADE QUICKLY AND
ECONOMICALLY, EVALUATED VISUALLY, AND EASILY
REPAIRED IF NECESSARY,
THE LOW TEMPERATURES EMPLOYED FOR SOLDERING
MINIMIZE DISTORTION AND HEAT DAMAGE TO THE
COMPONENTS BEING JOINED,
DISSIMILAR MATERIALS, SUCH AS CERAMIC-TO-METAL OR
GLASS-TO-METAL, MAY BE SOLDERED,
AND SOLDERING PROCESSES ARE EASILY AUTOMATED FOR
HIGH PRODUCTION.

SCENE 58.
continue previous shot

NARRATION (VO) :

FOR THESE REASONS, SOLDERING IS USED EXTENSIVELY
IN THE ELECTRONICS INDUSTRY.

SCENE 59.
59A, tape 808, 08:09:35-08:09:50
zoom out, soldered joint

NARRATION (VO) :

HOWEVER, SOLDERED JOINTS HAVE LIMITED MECHANICAL
STRENGTH COMPARED TO BRAZING, WELDING AND
MECHANICAL FASTENING.

SCENE 60.
60A, tape 808, 08:18:32-08:18:52
soldering operation
CG, SUPER: Low-Carbon Steels
 Copper & Many Copper
 Alloys
 Lead & Lead Alloys
 Tin & Tin Alloys
 Zinc

NARRATION (VO) :

SOLDERING IS USED TO JOIN A WIDE RANGE OF METALS.
AMONG THE MORE SOLDERABLE ARE:
LOW-CARBON STEELS,
COPPER AND MANY COPPER ALLOYS,
LEAD AND LEAD ALLOYS,
TIN AND TIN ALLOYS,

AND ZINC.

SCENE 61.

61A, tape 846, 02:03:59-02:04:45

zoom out, soldering flux being applied to assembly

CG, SUPER: Inorganic-Acid Fluxes
Organic-Acid Fluxes
Rosin-Based Fluxes

NARRATION (VO) :

FLUXES FOR THE RANGE OF SOLDERABLE MATERIALS ARE GENERALLY CLASSIFIED INTO THREE CATEGORIES: INORGANIC-ACID FLUXES, ORGANIC-ACID FLUXES, AND ROSIN-BASED FLUXES. THESE FLUXES MAY BE SOLVENT-BASED OR WATER-BASED.

SCENE 62.

62A, tape 849, 05:03:39-05:03:47

zoom out, soldering flux applied to assembly

62B, tape 847, 03:15:06-03:15:14
paste soldering flux

62C, tape 849, 06:13:34-06:13:41
powder soldering flux

62D, tape 845, 01:05:52-01:05:59
zoom out, coiled flux cored solder

62E, tape 847, 03:22:38-02:22:43
flux applied to component

62F, tape 847, 03:26:35-02:26:57
fluxed component placed in fixture for soldering, solder preform placed on component and then heated up

NARRATION (VO) :

LIKE BRAZING FLUXES, SOLDERING FLUXES ARE AVAILABLE IN MANY FORMS INCLUDING: LIQUIDS..., PASTES..., POWDERS..., AND AS FLUX-CORED SOLDER. THESE FLUXES ARE APPLIED USING MANY OF THE SAME METHODS AS IN BRAZING.

SCENE 63.

continue previous shot

CG, SUPER: Tin/Lead
Tin/Silver/Lead

63A, tape 848, 04:11:32-04:11:48
zoom out, wave soldering filler metal

CG, SUPER: Tin-Zinc
Silver-Copper-Zinc
Zinc-Aluminum Alloys

NARRATION (VO) :

SOLDERING FILLER METALS, COMMONLY REFERRED TO AS SOLDER, TYPICALLY CONTAIN TIN AND LEAD, OR TIN, SILVER AND LEAD AS THE PRIMARY INGREDIENTS. OTHER SOLDER COMPOSITIONS INCLUDE: TIN-ZINC, SILVER-COPPER-ZINC, AND ZINC-ALUMINUM ALLOYS.

SCENE 64.

64A, tape 848, 04:10:19-04:10:40
zoom out, ingot of solder

NARRATION (VO) :

64B, tape 849, 06:08:48-06:08:55 SOLDERS ARE AVAILABLE IN VARIOUS FORMS, WITH OR
solder sheet
64C, tape 794, 15:03:31-15:03:41 WITHOUT FLUX, INCLUDING:
zoom out, slitting solder foil
64D, tape 849, 06:03:55-06:04:06 CAKES OR INGOTS...,
solder wire
64E, tape 848, 04:03:14-04:03:20 SHEET...,
solder paste
64F, tape 847, 03:17:03-03:17:07 FOIL...,
zoom out, solder performs
WIRE...,
PASTE...,
AND PREFORMS.

SCENE 65.

65A, tape 846, 02:09:10-02:09:38
zoom out, wave soldering
operation
65B, tape 847, 03:02:10-03:02:18
circuit boards being washed

NARRATION (VO) :

WHEN HEATED, SOLDER AND FLUXES CAN BE IRRITATING
OR TOXIC, NECESSITATING PRECAUTIONS DURING
OPERATIONS. AFTERWARDS, RESIDUES FROM CORROSIVE
FLUXES ARE REMOVED AS REQUIRED.

SCENE 66.

66A, tape 854, 12:21:34-12:21:41
c.u. induction soldering
operation
66B, GRAPHIC: parts with
clearance
66C, GRAPHIC: c.u. joint area
66D, GRAPHIC: c.u. joint area,
double-sided arrow indicating
joint clearance
CG, SUPER: 0.003 Of An Inch/
0.08 Of A Millimeter
To 0.006 Of An Inch/
0.15 Of A Millimeter

NARRATION (VO) :

TO ENSURE ADEQUATE CAPILLARY FLOW, JOINT CLEARANCE
FOR SOLDERING OPERATIONS TYPICALLY RANGES FROM
THREE THOUSANDTHS OF AN INCH, OR EIGHT HUNDREDTHS
OF A MILLIMETER, TO SIX THOUSANDTHS OF AN INCH, OR
FIFTEEN HUNDREDTHS OF A MILLIMETER.

SCENE 67.

67A, tape 847, 03:23:57-03:24:37
c.u., torch soldering
CG, SUPER: Torch Soldering
Furnace Soldering
Dip Soldering
Induction Soldering

NARRATION (VO) :

MANY SOLDERING PROCESSES ARE SIMILAR TO BRAZING
PROCESSES, EXCEPT THEY ARE PERFORMED AT LOWER
TEMPERATURE. THESE PROCESSES INCLUDE:
TORCH SOLDERING,
FURNACE SOLDERING,
DIP SOLDERING,

AND INDUCTION SOLDERING.

SCENE 68.

68A, tape 845, 01:26:42-01:26:50
zoom in, iron soldering
CG, SUPER: Iron Soldering
68B, tape 846, 02:24:44-02:24:58
wave soldering operation
CG, SUPER: Wave Soldering

NARRATION (VO) :

PROCESSES UNIQUE TO SOLDERING INCLUDE:
IRON SOLDERING...,
AND WAVE SOLDERING.

SCENE 69.

CG, SUPER: Iron Soldering
69A, tape 845, 01:25:59-01:26:07
zoom out, soldering operation
69B, tape 845, 01:11:28-01:11:35
zoom out, soldering operation
69C, tape 845, 01:18:31-01:18:42
zoom in, iron soldering of
assembly
69D, tape 845, 01:20:32-01:20:43
copper tip heating joint, solder
applied filling joint gap

NARRATION (VO) :

IRON SOLDERING USING CONVENTIONAL SOLDERING IRONS
IS THE OLDEST SOLDERING METHOD AND IS STILL WIDELY
USED. SOLDERING IRONS HAVE A COPPER TIP MOUNTED TO
A HEAT RESISTANT HANDLE. THE COPPER TIP STORES AND
TRANSFERS HEAT TO THE JOINT. ONCE THE JOINT IS UP
TO SOLDERING TEMPERATURE, SOLDER IS APPLIED
BETWEEN THE IRON TIP AND THE ASSEMBLY JOINT TO
MELT AND FORM THE BOND.

SCENE 70.

70A, tape 845, 01:08:52-01:09:03
zoom out, traditional iron
soldering iron
70B, tape 808, 08:16:48-08:16:58
soldering iron heated by direct
flame

NARRATION (VO) :

SOLDERING IRONS ARE AVAILABLE IN VARIOUS FORMS AND
ARE COMMONLY HEATED ELECTRICALLY, BUT IRONS MAY
ALSO BE HEATED BY DIRECT FLAME OR IN OVENS.

--- TOUCH BLACK ---

SCENE 71.

CG, SUPER: Wave Soldering
71A, tape 846, 02:09:56-02:10:28
zoom in, wave soldering of
circuit boards

NARRATION (VO) :

WAVE SOLDERING IS USED FOR AUTOMATED SOLDERING OF
ELECTRONIC COMPONENTS ONTO PRINTED CIRCUIT BOARDS.

SCENE 72.

continue previous shot

NARRATION (VO) :

IN WAVE SOLDERING, THE SOLDER IS LIFTED TO THE
CONNECTION JOINTS BY ONE OR MORE STANDING
FOUNTAINS, OR WAVES, OF CONTINUOUSLY CIRCULATED,

FRESH, HOT SOLDER. AT ANY GIVEN TIME, ONLY A SMALL BAND OF THE ASSEMBLY IS IMMERSSED IN THE WAVE, ELIMINATING EXPOSURE OF THE CIRCUIT BOARD TO EXCESS HEAT.

SCENE 73.

73A, tape 847, 03:05:12-03:05:36
under wave soldered circuit board

73B, tape 846, 02:20:30-02:20:50
zoom out, wave soldering of circuit boards

NARRATION (VO) :

A MULTITUDE OF PRINTED-CIRCUIT-BOARD JOINTS ARE SOLDERED IN SECONDS BY WAVE SOLDERING. BECAUSE THE OPERATION IS FAST, IT REDUCES ASSEMBLY WARPAGE, AS WELL AS AIR, FLUX AND VAPOR ENTRAPMENT DURING SOLDERING.

SCENE 74.

74A, tape 848, 04:24:21-04:24:44
pan, wave soldering machine from fluxing to washer

NARRATION (VO) :

WAVE SOLDERING MACHINES ARE AVAILABLE THAT FLUX...,
PREHEAT...,
SOLDER...,
AND CLEAN FLUX RESIDUE OFF THE FINISHED PRINTED-CIRCUIT-BOARDS WHILE ON A SINGLE CONVEYOR TRANSPORT.

--- FADE TO BLACK ---

SCENE 75.

CG: Review

white text on black

75A, peter carey narration

75B, tape 63, 12:00:15-12:03:49
review music

MUSIC UP AND UNDER

NARRATION (VO) :

LET'S REVIEW THE MATERIAL CONTAINED IN THIS PROGRAM.

SCENE 76.

76A, tape 853, 11:22:18-11:22:28
brazing operation

76B, tape 848, 04:15:45-04:16:13
circuit board soldering operation

76C, tape 847, 03:06:38-03:06:53
zoom in, circuit board

NARRATION (VO) :

BRAZING...,
AND SOLDERING ARE JOINING PROCESSES THAT USE HEAT, FILLER METAL,

AND USUALLY FLUX TO PRODUCE A METALLURGICAL BOND
BETWEEN MATERIALS.

SCENE 77.

77A, tape 857, 16:22:13-16:22:29

zoom out, furnace brazing
operation

77B, tape 854, 12:25:06-12:25:26

zoom out, soldering operation

77C, tape 851, 08:25:31-08:25:52

zoom in, induction brazing
operation

77D, tape 847, 03:14:10-03:14:27

torch soldering operation

NARRATION (VO) :

BRAZING...

AND SOLDERING ARE SIMILAR IN PROCESS, WITH THE
MAIN DIFFERENCE BEING THAT BRAZING IS PERFORMED
USING A FILLER METAL HAVING A MELTING, OR
LIQUIDOUS, TEMPERATURE 'ABOVE' 840 DEGREES
FAHRENHEIT, OR 450 DEGREES CELSIUS, WHILE THE
FILLER METALS USED IN SOLDERING HAVE LIQUIDOUS
TEMPERATURES 'BELOW' 840 DEGREES FAHRENHEIT, OR
450 DEGREES CELSIUS.

SCENE 78.

78A, tape 808, 08:11:16-08:11:30

c.u., zoom out, filler metal
added to brazing operation

NARRATION (VO) :

THE FILLER METALS FOR BOTH BRAZING AND SOLDERING
ARE TYPICALLY HELD IN, OR DISTRIBUTED BETWEEN
CLOSELY FITTED, INTERFACING, OR FAYING, JOINT
SURFACES BY CAPILLARY ACTION.

SCENE 79.

79A, tape 860, 19:15:44-19:16:04

c.u. filler metal added to
brazing operation

79B, ANI: liquefied filler metal

drawn into joint between two
parallel surfaces through
capillary action

79C, GRAPHIC: last frame of
animation, cooled down

NARRATION (VO) :

CAPILLARY ACTION OCCURS BECAUSE THE ATOMS OF THE
LIQUEFIED FILLER METAL HAVE STRONGER ATTRACTION TO
THE BASE METALS' ATOMS THAN TO THEIR OWN. WHEN
THIS ATTRACTION OCCURS BETWEEN TWO SURFACES, THE
LIQUID EVENLY DISTRIBUTES ITSELF.

SCENE 80.

80A, tape 860, 19:08:40-19:09:00

fluxed part brazed

NARRATION (VO) :

IN MANY CASES, FLUX IS USED TO ASSIST IN THE
PROPER DISTRIBUTION OF FILLER METAL.

SCENE 81.

81A, tape 855, 13:02:36-13:02:48

NARRATION (VO) :

removal of flux in acid bath
after joining

81B, tape 861, 20:17:30-20:17:55
mechanical cleaning of flux
residue

FLUX RESIDUE IS CORROSIVE, SO ITS REMOVAL AFTER
JOINING IS ESSENTIAL. SOAKING IN HOT OR WARM WATER
IS A COMMON PROCEDURE, BUT MECHANICAL CLEANING MAY
SOMETIMES BE NECESSARY.

SCENE 82.

82A, tape 856, 15:27:39-15:27:48
zoom in, filler metal added to
joint

82B, tape 850, 07:19:10-07:19:38
zoom out, filler metal added to
joint

CG, SUPER: Aluminum-Silicon
Copper
Copper-Phosphorus
Magnesium
Silver
Nickel Alloys

NARRATION (VO):

THE TYPE OF FILLER METAL USED FOR BRAZING DEPENDS
ON THE BASE METAL OR MATERIALS BEING JOINED. THE
MOST COMMON FILLER METALS INCLUDE:

ALUMINUM-SILICON,

COPPER,

COPPER-PHOSPHORUS,

MAGNESIUM,

SILVER,

AND NICKEL ALLOYS.

SCENE 83.

83A, tape 861, 20:05:26-20:05:36
torch brazing operation

CG, SUPER: Torch Brazing

83B, tape 855, 14:17:40-14:17:54
assemblies coming out of batch
furnace

CG, SUPER: Batch Furnace Brazing

83C, tape 858, 17:07:43-17:08:06
zoom out, assemblies conveyed
into furnace

CG, SUPER: Continuous Furnace
Brazing

83D, tape 854, 12:05:13-12:05:25
assembly dipped in molten
chemical bath

CG, SUPER: Dip Brazing

83E, tape 853, 11:19:11-11:19:30
zoom in, induction brazing
operation

CG, SUPER: Induction Brazing

NARRATION (VO):

COMMON METHODS OF BRAZING, INCLUDE:

TORCH BRAZING...,

BATCH FURNACE BRAZING...,

CONTINUOUS FURNACE BRAZING...,

DIP BRAZING...,

AND INDUCTION BRAZING.

SCENE 84.

84A, tape 845, 01:08:06-01:08:24
zoom in, iron soldering

NARRATION (VO):

SOLDERING PROCESSES ARE SOME OF THE OLDEST METHODS

USED TO JOIN METALS, WITH MOST PRODUCING AN INTER-METALLIC-TYPE METALLURGICAL BOND BETWEEN THE SOLDER AND BASE MATERIALS.

SCENE 85.

85A, tape 847, 03:26:35-02:26:57
fluxed component placed in
fixture for soldering, solder
preform placed on component and
then heated up

CG, SUPER: Tin/Lead

Tin/Silver/Lead

85B, tape 848, 04:11:32-04:11:48
zoom out, wave soldering filler
metal

CG, SUPER: Tin-Zinc

Silver-Copper-Zinc

Zinc-Aluminum Alloys

NARRATION (VO) :

SOLDERING FILLER METALS, COMMONLY REFERRED TO AS SOLDER, TYPICALLY CONTAIN TIN AND LEAD, OR TIN, SILVER AND LEAD AS THE PRIMARY INGREDIENTS. OTHER

SOLDER COMPOSITIONS INCLUDE:

TIN-ZINC,

SILVER-COPPER-ZINC,

AND ZINC-ALUMINUM ALLOYS.

SCENE 86.

86A, tape 847, 03:23:57-03:24:37
c.u., torch soldering

CG, SUPER: Torch Soldering

Furnace Soldering

Dip Soldering

Induction Soldering

NARRATION (VO) :

MANY SOLDERING PROCESSES ARE SIMILAR TO BRAZING PROCESSES, EXCEPT THEY ARE PERFORMED AT LOWER TEMPERATURE. THESE PROCESSES INCLUDE:

TORCH SOLDERING,

FURNACE SOLDERING,

DIP SOLDERING,

AND INDUCTION SOLDERING.

SCENE 87.

87A, tape 845, 01:26:42-01:26:50
zoom in, iron soldering

CG, SUPER: Iron Soldering

87B, tape 846, 02:09:56-02:10:28
zoom in, wave soldering of
circuit boards

CG, SUPER: Wave Soldering

NARRATION (VO) :

PROCESSES UNIQUE TO SOLDERING INCLUDE:

IRON SOLDERING...,

AND WAVE SOLDERING, WHICH IS USED EXTENSIVELY TO

PRODUCE ELECTRONIC CIRCUIT BOARDS.

--- FADE TO BLACK ---

SCENE 88.

CG, ROLL: credits

white text on black, fade up
mid-screen

Produced By:

Society of Manufacturing Engineers

88A, GRAPHIC: AFFT logo

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Brite Brazing
Carbide Tool Works, Inc.
Franklin Brazing & Metal Treating
Hi Tecmetal Group
KMC Controls
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SCENE 89.

CG: disclaimer

white text centered on black

Some machinery in this program had safety
equipment removed to allow better recording of
certain processes.

Always read the safety information provided in the
manufacturers' manual before machine operation.

SCENE 90.

90A, tape 40, 01:00:00-01:00:12

SME logo

CG, SUPER: www.sme.org