

FUNDAMENTAL MANUFACTURING PROCESSES

Hydroforming

SCENE 1.

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

WARNING

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criminal penalties for the unauthorized
reproduction, distribution or exhibition
of copyrighted videotapes.

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SCENE 2.

CG: disclaimer
white text centered on black to
blue gradient

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

SCENE 3.

CG: AFFT screen A
white text centered on black to
blue gradient
tape 715, 01:01:10-01:01:50
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 hydroforming, please visit
our website at:
www.sme.org/afft

SCENE 5.

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

SCENE 6.

tape 25, 01:01:00-01:01:45
fundamental series open, with
music
tape 764, 01:00:00-01:04:52
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: Hydroforming
white text centered on black

NARRATION (VO) :

THIS PROGRAM EXPLORES THE FUNDAMENTALS OF
HYDROFORMING.

SCENE 8.

tape 293, 02:01:14-02:01:36
c.u. sheet metal stamping
operation
tape 292, 01:14:55-01:15:15
wide, press and stamping
operation

NARRATION (VO) :

THE MOST COMMONLY USED METHOD FOR SHAPING SHEET
METAL COMPONENTS IS BY MEANS OF MATING DIE HALVES
APPLIED TO BLANK MATERIAL. THE DIE-CLOSING FORCE
IS DEVELOPED BY A STAMPING PRESS, AND THE TOOLING
SHAPES THE WORKPIECE BY DIRECT CONTACT WITH THE
SHEET METAL MATERIAL.

SCENE 9.

tape 759, 06:22:10-06:22:39
hydroforming operation ending

NARRATION (VO) :

HYDROFORMING, IN CONTRAST, USES FLUID PRESSURE
APPLIED TO A BLANK TO FORM THE DESIRED COMPONENT
SHAPE.

SCENE 10.

tape 754, 01:21:56-01:22:05
tubular blank placed in
hydroforming press
tape 748, 03:03:33-03:03:42
sheet metal blank placed in
hydroforming press
tape 757, 00:12:01-00:12:07
tubular hydroforming operation
beginning, dissolve into next
shot
tape 757, 00:12:33-00:12:41
tubular hydroforming operation
ending
CG, SUPER: Tubular Hydroforming
tape 752, 10:03:34-10:03:50
sheet metal hydroforming
operation ending emphasizing
tooling
CG, SUPER: Sheet Metal
Hydroforming

NARRATION (VO) :

BLANKS USED IN THE HYDROFORMING PROCESS CAN BE
EITHER TUBULAR MATERIAL...,
OR SHEET METAL MATERIAL.
SHEET-,
AND TUBULAR- HYDROFORMING EACH HAVE SPECIFIC
HYDROFORMING PROCESS REQUIREMENTS. FOR THIS
REASON, OPERATIONS ARE TYPICALLY DEFINED AS EITHER
TUBULAR HYDROFORMING...,
OR SHEET METAL HYDROFORMING.

SCENE 11.

tape 756, 00:18:56-00:19:07
pan, steel sheet metal to steel

NARRATION (VO) :

tubes ready for hydroforming
tape 748, 03:13:27-03:13:39
zoom in, preparing blanks for hydroforming
CG, SUPER: Exhibit Good Fatigue Properties
High-Energy Absorption
Acceptable Corrosion Resistance When Coated
Excellent Forming Properties

tape 741, 02:25:12-02:25:22
pan, tubing for hydroforming
CG, SUPER: Stainless Steels
Aluminum
Copper
Copper Alloys

SCENE 12.

tape 757, 00:07:54-00:08:04
hydroforming operation, tooling coming down
tape 755, 02:15:22-02:15:27
wide, hydraulic press used in hydroforming operation
tape 756, 00:28:39-00:28:46
pan, fluid pressure intensification system

SCENE 13.

tape 752, 10:22:12-10:22:22
sheet metal hydroforming tooling
tape 750, 01:20:08-01:20:18
tubular hydroforming tooling with single cavity
tape 757, 00:04:09-00:04:19
zoom out, multi-cavity tooling for tubular hydroforming operation

SCENE 14.

tape 752, 10:00:02-10:00:13
wide, dolly in, hydraulic press used for sheet metal hydroforming
tape 746, 01:05:00-01:05:10
zoom in, hydraulic press used for rubber diaphragm forming, gage showing pressure
tape 290, 02:03:50-02:03:58
mechanical press operating part coming out of deep draw

THE MOST COMMONLY USED MATERIALS FOR HYDROFORMING
BLANKS INCLUDE VARIOUS GRADES OF STEEL. THESE
MATERIALS EXHIBIT GOOD FATIGUE PROPERTIES, HIGH-
ENERGY ABSORPTION, ACCEPTABLE CORROSION RESISTANCE
WHEN COATED, AND EXCELLENT FORMING PROPERTIES.
OTHER MATERIALS USED FOR HYDROFORMING INCLUDE:
STAINLESS STEELS,
ALUMINUM,
COPPER,
AND COPPER ALLOYS.

NARRATION (VO):

ALL HYDROFORMING OPERATIONS REQUIRE HYDROFORMING
TOOLING AND DIES...,
A HYDRAULIC PRESS...,
AND A FLUID-PRESSURE INTENSIFICATION SYSTEM.

NARRATION (VO):

SHEET-...,
AND TUBULAR HYDROFORMING TOOLING AND DIES VARY
DRAMATICALLY. THIS TOOLING MAY BE SINGLE
CAVITY...,
OR MULTI-CAVITY TO INCREASE PRODUCTION RATES.

NARRATION (VO):

HYDRAULIC PRESSES FOR HYDROFORMING PROVIDE THE
DIE-CLOSING FORCE AGAINST WHICH THE HIGH FLUID
PRESSURES ARE GENERATED TO FORM PARTS. THE FULL
FORCE OF THE HYDRAULIC PRESS CAN BE DELIVERED AT
ANY POINT IN THE STROKE, NOT JUST AT THE BOTTOM OF

operation

tape 750, 01:23:35-01:23:50

pan, zoom in, hydraulic press
used for tubular hydroforming

tape 741, 02:12:09-02:12:19

hydraulic press used for
pressure sequencing hydroforming

THE STROKE AS WITH A MECHANICAL PRESS. THE STROKE
OF A HYDRAULIC PRESS ALSO CAN BE ADJUSTED TO
PROVIDE OPTIMAL PART CLEARANCE BEFORE CYCLING
AGAIN. MOREOVER, HYDRAULIC PRESSES CAN BE STOPPED
IN MID-STROKE WHICH IS ADVANTAGEOUS FOR SOME
HYDROFORMING APPLICATIONS.

SCENE 15.

tape 750, 01:01:53-01:02:10

pan, fluid pressure
intensification system for
hydroforming

tape 759, 06:20:18-06:20:31

zoom in, hydroforming operation
with a lot of fluid

CG, SUPER: Lubricants
Drying Agents
Rust Preventatives
Bactericides

NARRATION (VO) :

THE FLUID-PRESSURE INTENSIFICATION SYSTEM MAINLY
CONSISTS OF A LOW-PRESSURE, HIGH FLOW RATE FILLING
SYSTEM, AND A HIGH-PRESSURE INTENSIFIER TO RAISE
THE FLUID TO THE REQUIRED FORMING PRESSURE. THE
FORMING FLUID IS WATER-BASED WITH ADDITIVES SUCH
AS LUBRICANTS, DRYING AGENTS, RUST PREVENTATIVES,
AND BACTERICIDES.

SCENE 16.

tape 759, 06:16:13-06:16:20

tubular hydroforming blank
placed on the lower tooling,
dissolve into next shot

tape 759, 06:16:21-06:16:27

die closed over tooling

tape 763, 00:02:58-00:03:10

ANI: fluid pressure applied in
tubular blank

tape 763, 00:05:14-00:05:26

ANI: fluid pressure applied in
sheet metal blank, blank
deforming into shape of tooling

tape 752, 10:06:32-10:06:45

zoom out, sheet metal
hydroforming operation ending

NARRATION (VO) :

IN A TYPICAL HYDROFORMING OPERATING CYCLE, A BLANK
IS PLACED ON THE LOWER TOOLING...,
THEN THE PRESS IS CLOSED...,
FLUID PRESSURE IS THEN APPLIED INTO THE TUBULAR
SECTION...,
OR ONTO ONE SIDE OF THE SHEET METAL BLANK...,
THE MAGNITUDE OF PRESSURE IS HIGH ENOUGH TO CAUSE
THE BLANK MATERIAL TO DEFORM PLASTICALLY, TAKING
THE SHAPE OF THE TOOLING.

SCENE 17.

tape 749, 04:02:21-04:02:34

zoom in, lubricant being applied
to blank before hydroforming

tape 748, 03:28:49-03:29:05

same lubricated part coming out
of hydroforming process

NARRATION (VO) :

LUBRICANTS ARE ESPECIALLY IMPORTANT IN
HYDROFORMING...,

LUBRICANTS ASSIST IN REDUCING THE FRICTION
STRESSES, OR FORCES AT THE TOOL-BLANK INTERFACE,
THUS IMPROVING METAL FLOW.

SCENE 18.

tape 758, 05:08:40-05:08:44
hydroforming operation, parts in
press, press closed, dissolve
into next shot

tape 758, 05:08:48-05:08:54
hydroforming of parts, dissolve
into next shot

tape 758, 05:09:03-05:09:12
hydroforming operation, press
opens with hydroformed parts

tape 751, 02:12:49-02:12:52
flop shot, c.u. hydro-piercing
punch activating, dissolve into
next shot

tape 751, 02:11:27-02:11:34
flop shot, part ejected from
hydroforming die, showing
piercing

tape 741, 02:19:23-02:19:30
hydroformed stamped part being
trimmed

NARRATION (VO) :

THERE ARE SEVERAL ADVANTAGES TO HYDROFORMED
COMPONENTS OVER CONVENTIONALLY MANUFACTURED PARTS:
CONVENTIONALLY PRODUCED MULTI-COMPONENT PARTS CAN
BE HYDROFORMED FROM A SINGLE BLANK, REDUCING PART
COUNT AND POSSIBLY WEIGHT...,
MOST, IF NOT ALL, FORMING AND PIERCING OPERATIONS
CAN BE PERFORMED WITHIN A SINGLE HYDROFORMING SET-
UP...,
AND SCRAP RATES FOR HYDROFORMING CAN BE
SIGNIFICANTLY LOWER THAN TRADITIONAL STAMPING
SCRAP RATES.

SCENE 19.

tape 761, 10:12:37-10:12:45
wide, hydroforming of part

tape 762, 11:14:30-11:14:37
pan, automobile in showroom

tape 483, 11:04:12-11:04:19
jet taking off

tape 756, 00:30:25-00:30:29
hydroformed appliance handle

tape 762, 12:01:40-12:01:50
hydroformed plumbing t-fitting

NARRATION (VO) :

FOR THESE REASONS, MANY MAJOR INDUSTRIES USE
HYDROFORMED COMPONENTS, INCLUDING:
THE AUTOMOTIVE...,
AEROSPACE...,
APPLIANCE...,
AND PLUMBING INDUSTRIES.

--- FADE TO BLACK ---

SCENE 20.

CG: Tubular Hydroforming
white text centered on black

SCENE 21.

tape 764, 01:04:56-01:11:45
peter carey narration

tape 759, 06:17:45-06:17:58

NARRATION (VO) :

TUBULAR HYDROFORMING BEGINS WITH THE PLACEMENT OF

tubular hydroforming operation,
straight tube placed into die
tape 740, 01:02:58-01:03:04
tubular hydroforming operation,
bent tube placed into die

STRAIGHT TUBES INTO THE DIE...,
BUT IS MORE COMMONLY BEGUN USING PREFORMED TUBES.

SCENE 22.

tape 750, 01:08:58-01:09:10
wide, bent tube taken out of
preforming die

NARRATION (VO) :

PREFORMING PREPARES THE TUBE BY SHAPING IT
GENERALLY INTO FORM FOR PLACEMENT INTO THE
HYDROFORMING DIE.

SCENE 23.

tape 740, 01:08:17-01:08:32
tube being bent on rotary draw
bending machine before
hydroforming
tape 750, 01:02:55-01:03:02
c.u. part bent in preforming die
tape 754, 01:22:31-01:22:47
tube being bent during the
hydroforming operation

NARRATION (VO) :

TUBE PREFORMING CAN BE DONE BEFORE HYDROFORMING
USING EITHER A ROTARY DRAW BENDING METHOD...,
AND/OR A PREFORMING DIE...,
PREFORMING ALSO CAN BE DONE DURING THE
HYDROFORMING OPERATION, WHICH IS REFERRED TO AS
HYDRO-BENDING.

SCENE 24.

tape 763, 00:06:05-00:06:08
ANI: press closing, dissolve
into next shot
tape 763, 00:06:09-00:06:12
ANI: sealing punch moves into
position, sealing tube end,
dissolve into next shot
tape 763, 00:06:54-00:07:01
ANI: fluid pressurization of
tube begins
tape 759, 06:20:42-06:21:10
c.u., zoom out, sealing punches
moving into place on
hydroforming press

NARRATION (VO) :

SEALING PUNCHES WITHIN THE DIE CLOSE THE ENDS OF
THE TUBE WHILE THE NECESSARY FLUID PRESSURIZATION
OF THE TUBE BEGINS FOR HYDROFORMING. THIS FLUID
PRESSURIZATION TYPICALLY REMOVES WRINKLES OR
IMPERFECTIONS IN THE TUBE.

SCENE 25.

tape 760, 07:03:20-07:03:44
zoom out, sealing punch and tube
end in die, hydroforming started
CG, SUPER: Outside Diameter
 Inside Diameter
 End Surface

NARRATION (VO) :

THERE ARE THREE SURFACES AT THE END OF A TUBE THAT
CAN BE USED AS A SEALING SURFACE. THESE ARE THE
OUTSIDE DIAMETER,

INSIDE DIAMETER,
AND END SURFACE.

SCENE 26.

tape 763, 00:08:35-00:08:55

ANI: fluid pressure applied in tubular blank within die, simultaneous pressing on tube ends by sealing punches cause material to flow into the contours of the die, finishing part

NARRATION (VO) :

DURING FORMING, A COMBINATION OF INCREASED INTERNAL PRESSURE AND A SIMULTANEOUS AXIAL PRESSING ON THE TUBE ENDS BY THE SEALING PUNCHES CAUSES THE MATERIAL TO FLOW INTO THE CONTOURS OF THE DIE AND THE FORMING ZONES.

SCENE 27.

tape 759, 06:27:03-06:27:26

low-pressure hydroforming operation ending
CG, SUPER: Low-Pressure Hydroforming/LPH

tape 750, 01:19:33-01:19:51

high-pressure hydroforming operation ending
CG, SUPER: High-Pressure Hydroforming/HPH

tape 740, 01:28:22-01:28:29

pressure sequence hydroforming operation
CG, SUPER: Pressure Sequence Hydroforming/PSH

NARRATION (VO) :

TUBULAR HYDROFORMING IS GENERALLY DIVIDED INTO THREE CLASSIFICATIONS OR OPERATING TECHNIQUES: LOW-PRESSURE HYDROFORMING, OR 'LPH'..., HIGH-PRESSURE HYDROFORMING, OR 'HPH'..., AND PRESSURE SEQUENCE HYDROFORMING, OR 'PSH'.

SCENE 28.

CG, SUPER: Low-Pressure Hydroforming

tape 759, 06:28:08-06:28:22

wide, low-pressure hydroforming operation beginning
CG, SUPER: 12,000 psi/828 bar

NARRATION (VO) :

LOW-PRESSURE HYDROFORMING IS COMMONLY DEFINED AS HYDROFORMING AT FLUID PRESSURES BELOW 12,000 'PSI', OR POUNDS PER SQUARE INCH, OR 828 'BAR'.

SCENE 29.

tape 759, 06:29:29-06:29:40

low-pressure hydroforming operation ending

tape 760, 07:04:43-07:05:01

zoom out, parts produced from low-pressure hydroforming

NARRATION (VO) :

PRODUCTION CYCLE TIME FOR LOW-PRESSURE HYDROFORMING IS TYPICALLY LOWER THAN THAT OF HIGH-PRESSURE HYDROFORMING, BUT COMPONENTS MUST BE CAREFULLY DESIGNED TO FORM PROPERLY USING THE LOWER FLUID PRESSURES.

--- TOUCH BLACK ---

SCENE 30.

CG, SUPER: High-Pressure
Hydroforming

tape 751, 02:04:18-02:04:24

high pressure hydroforming
operation, blank placed in the
die

tape 751, 02:04:30-02:04:39

high pressure hydroforming
operation, die halves closed

tape 763, 00:10:07-00:10:18

ANI: pressurized fluid injected
into the blank, filling the
material out to the die shape

NARRATION (VO) :

WITH HIGH-PRESSURE HYDROFORMING, TUBE BLANKS ARE
PLACED IN THE DIE...,
AND THE DIE HALVES CLOSED WITHOUT PRESSURIZED
FLUID IN THE BLANK...,
ONCE CLOSED, PRESSURIZED FLUID IS THEN INJECTED
INTO THE BLANK, COMPLETELY FILLING THE MATERIAL
OUT TO THE SHAPE OF THE DIE.

SCENE 31.

tape 754, 01:29:02-01:29:28

zoom out, high pressure
hydroforming operation

CG, SUPER: 20,000 psi/1,379 bar
100,000 psi/6,895 bar

CG, SUPER: Material Yield
Strength

Tube Wall Thickness
Inside Radius of the
Sharpest Cross-
Sectional Corner

NARRATION (VO) :

IN HIGH-PRESSURE HYDROFORMING, FLUID PRESSURE
COMMONLY EXCEEDS 20,000 'PSI', OR 1,379 'BAR', AND
CAN REACH 100,000 'PSI', OR 6,895 'BAR'. ACTUAL
PRESSURE NEEDED IS DEPENDENT UPON SEVERAL FACTORS
SUCH AS MATERIAL YIELD STRENGTH, TUBE WALL
THICKNESS AND THE INSIDE RADIUS OF THE SHARPEST
CROSS-SECTIONAL CORNER.

SCENE 32.

tape 763, 00:11:00-00:11:08

ANI: c.u. corner of die with
blank expanding into it with
inconsistent wall thickness

tape 753, 00:05:22-00:05:33

pan, large presses used to
perform high pressure
hydroforming

NARRATION (VO) :

WHEN THE TUBE IS EXPANDED BY HIGH PRESSURE WITHIN
THE DIE CAVITY, MATERIAL THICKNESS MAY VARY
THROUGHOUT THE PART. ADDITIONALLY, LARGER PRESSES
ARE NEEDED FOR HIGH-PRESSURE HYDROFORMING AND THE
HIGHER OPERATING PRESSURES CAN RESULT IN LONGER
CYCLE TIMES.

--- TOUCH BLACK ---

SCENE 33.

CG, SUPER: Pressure Sequence
Hydroforming

NARRATION (VO) :

tape 740, 01:05:38-01:05:46
pressure sequence hydroforming,
blank in die and die partially
closed

tape 740, 01:24:25-01:24:33
pressure sequence hydroforming,
blank placed in die and die
partially closed

tape 763, 00:12:00-00:12:06
ANI: pressure sequence
hydroforming operation, low-
pressurized fluid is pumped into
the blank, dissolve into next
shot

tape 763, 00:12:30:00
GRAPHIC: freeze frame from
animation, part with pressure
arrows

SCENE 34.

tape 763, 00:12:30-00:12:48
continue previous animation die
starts to close again, deforming
part more

SCENE 35.

tape 763, 00:13:09-00:13:21
continue previous animation,
high pressure applied to fluid
forcing material into the
corners of die cavity
tape 763, 00:13:58-00:14:05
ANI: c.u. high pressure applied
to fluid forcing material into
the corners of die cavity

SCENE 36.

continue previous animation
tape 741, 02:20:22-02:20:33
complex part produced from
pressure sequence hydroforming
tape 742, 03:05:26-03:05:30
complex part produced from
pressure sequence hydroforming
placed in rack
tape 740, 01:27:01-01:27:08
zoom in, pressure sequence

IN PRESSURE SEQUENCE HYDROFORMING, THE CLOSING
ACTION OF THE PRESS ASSISTS IN THE HYDROFORMING OF
THE BLANK. THE BLANK IS FIRST PLACED IN THE DIE
CAVITY AND THE DIE IS PARTIALLY CLOSED, PARTLY
DEFORMING THE TUBE. LOW-PRESSURIZED FLUID IS THEN
PUMPED INTO THE BLANK ALLOWING IT TO RESIST
COMPRESSION. AT THIS POINT, THE BLANK IS MUCH LIKE
A FORMABLE SOLID.

NARRATION (VO) :

THE DIE STARTS TO CLOSE AGAIN WITH THE DESIRED
LOW-PRESSURE MAINTAINED WHILE PART CROSS SECTION
REDUCES. LOW INTERNAL PRESSURE DURING DIE CLOSURE
DISCOURAGES PINCHING BETWEEN THE DIE HALVES. THIS
LIQUID PRESSURE ALSO RESISTS UNWANTED INWARD
DEFORMATION.

NARRATION (VO) :

ONCE THE DIE IS FULLY CLOSED, HIGH PRESSURE IS
APPLIED TO THE FLUID, FORCING MATERIAL INTO THE
CORNER RECESSES OF THE DIE CAVITY.

NARRATION (VO) :

WHEN PROPERLY DESIGNED AND MANAGED, COMPLEX SHAPES
CAN BE GENERATED FROM TUBES WITH LESS PRESSURE
THAN THAT NEEDED FOR OTHER HYDROFORMING
TECHNIQUES. MAXIMUM PRESSURE IS TYPICALLY UNDER

hydroforming operation
CG, SUPER: 10,000 psi/690 bar

10,000 'PSI', OR 690 'BAR'.

SCENE 37.

continue previous shot
tape 763, 00:14:37-00:14:49
ANI: c.u. corner of die with
blank expanding into it with
consistent wall thickness

NARRATION (VO) :

ALSO WITH PRESSURE SEQUENCE HYDROFORMING, THE TUBE
IS FORCED INTO THE DESIRED LOCATION AND SHAPE WITH
NO WALL THINNING, AS THE CAVITY AND BLANK ARE OF
THE SAME PERIPHERY, AND LEAVE NO ROOM TO EXPAND.

SCENE 38.

tape 751, 02:05:42-02:05:47
high pressure hydroforming
operation
tape 740, 01:27:12-01:27:20
pressure sequence hydroforming
operation ending, part taken out
tape 740, 01:27:36-01:27:45
pressure sequence hydroforming
operation, new part placed in
die, cycle started again

NARRATION (VO) :

HIGH-PRESSURE HYDROFORMING...,
AND PRESSURE SEQUENCE HYDROFORMING BOTH EFFECT THE
FORMING MECHANISMS OF MATERIALS DIFFERENTLY. FOR
THIS REASON, SELECTION OF THE RIGHT MATERIAL IS
FUNDAMENTAL TO SUCCESSFUL PRODUCTION.

--- TOUCH BLACK ---

SCENE 39.

tape 751, 02:10:53-02:11:05
hydro-piercing punch activating,
dissolve into next shot

NARRATION (VO) :

HYDROFORMING ALSO ALLOWS FOR MANY SECONDARY
OPERATIONS TO BE PERFORMED WITHIN THE PROCESS.

SCENE 40.

tape 751, 02:11:12-02:11:19
hydro-piercing punch retracting,
dissolve into next shot
tape 751, 02:11:27-02:11:34
part ejected from hydroforming
die, showing piercing
tape 763, 00:15:21-00:15:31
ANI: hydro-piercing operation,
punch creating opening against
pressurized fluid
CG, SUPER: Hydro-Piercing

NARRATION (VO) :

THE MOST DIMENSIONALLY STABLE, ROBUST AND
ECONOMICAL WAY TO GENERATE HOLES OR SLOTS IN
TUBULAR HYDROFORMED PARTS IS TO PUNCH THEM IN THE
HYDROFORMING DIE DURING THE FORMING CYCLE. THIS IS
REFERRED TO AS HYDRO-PIERCING.

SCENE 41.

tape 751, 02:15:23-02:15:32
hydro-piercing tooling built
into hydroforming
tape 751, 02:12:49-02:12:55
c.u. hydraulic cylinder
activating punch

NARRATION (VO) :

HYDRO-PIERCING TOOLING IS BUILT INTO THE
HYDROFORMING DIE AND USES A HYDRAULIC CYLINDER TO

ACTIVATE THE PUNCH.

SCENE 42.

tape 763, 00:16:13-00:16:24

ANI: c.u. hydro-piercing operation, punch creating opening against pressurized fluid

tape 763, 00:16:48-00:17:06

ANI: hydro-piercing being generated outwardly

NARRATION (VO) :

HYDRO-PIERCINGS ARE TYPICALLY PIERCED INWARDLY, WITH THE PUNCH CREATING THE OPENING AGAINST THE PRESSURIZED FLUID. HYDRO-PIERCINGS ALSO MAY BE GENERATED OUTWARDLY USING A PLUNGER, OR BACKUP PUNCH, WHICH RETRACTS ONCE MAXIMUM FLUID PRESSURE IS REACHED WITHIN THE PART. THE FLUID PRESSURE CAUSES THE SURFACE MATERIAL TO FAIL, GENERATING THE HOLE.

SCENE 43.

tape 751, 02:18:28-02:18:35

part with multiple holes and slots, freeze first frame if needed

tape 751, 02:14:27-02:14:39

med, various hydro-piercing tooling on die activating and retracting

NARRATION (VO) :

GENERALLY, HOLES AND SLOTS CAN BE POSITIONED ANYWHERE ON THE SURFACE OF A HYDROFORMED PART. THE MAIN LIMITATION IS THE SPACE NEEDED TO ACCOMMODATE THE HYDRO-PIERCING UNITS ON THE TOOL AND STILL MAINTAIN STRUCTURAL INTEGRITY OF THE TOOL.

--- FADE TO BLACK ---

SCENE 44.

CG: Sheet Metal Hydroforming
white text centered on black

SCENE 45.

tape 764, 01:11:47-01:17:40

peter carey narration

tape 749, 04:10:32-04:10:38

sheet metal hydroforming operation ending, part taken out, dissolve into next shot

tape 749, 04:10:59-04:11:08

blank placed in press, cycle started

NARRATION (VO) :

IN SHEET METAL HYDROFORMING, CONTROLLED METAL FLOW DURING THE OPERATION MINIMIZES LOCALIZED STRESS CONCENTRATIONS THAT MAY CAUSE WORKPIECE BUCKLING OR WRINKLING.

SCENE 46.

tape 752, 10:04:21-10:04:48

wide, sheet metal hydroforming operation

NARRATION (VO) :

SHEET METAL HYDROFORMING CYCLE TIMES ARE

RELATIVELY SLOW WHEN COMPARED TO MASS PRODUCTION STAMPING. THIS MAY LIMIT ITS USE TO LOW-VOLUME RUNS OF HIGHLY SPECIALIZED PRODUCT DESIGNS.

SCENE 47.

tape 748, 03:01:31-03:01:34
rubber diaphragm forming
operation beginning, dissolve
into next shot

tape 748, 03:01:37-03:01:42
rubber diaphragm forming
operation ending
CG, SUPER: Rubber Diaphragm
Forming

tape 752, 10:09:33-10:09:41
zoom out, active hydro-
mechanical drawing operation
CG, SUPER: Active Hydro-
Mechanical Drawing

NARRATION (VO) :

THE COMMON METHODS OF HYDROFORMING SHEET METAL MATERIAL INCLUDE:
RUBBER DIAPHRAGM FORMING.,
AND ACTIVE HYDRO-MECHANICAL DRAWING.

SCENE 48.

CG, SUPER: Rubber Diaphragm
Forming

tape 761, 10:28:25-10:28:40
zoom in, rubber diaphragm
forming operation ending,
emphasizing the rubber diaphragm

tape 762, 13:00:40-13:01:20
GRAPHIC: rubber diaphragm
forming press

GRAPHIC: add scrolling arrow
showing rubber diaphragm
GRAPHIC: add scrolling arrow
showing wear-pad

tape 747, 02:11:25-02:11:32
zoom in, rubber diaphragm
forming operation ending

NARRATION (VO) :

IN RUBBER DIAPHRAGM FORMING, A FLUID FORMING CHAMBER IS ATTACHED TO THE SLIDES OF A HYDRAULIC PRESS. FLUID IS RETAINED WITHIN THE CHAMBER BY A FLEXIBLE RUBBER DIAPHRAGM, WHICH SERVES AS A UNIVERSAL DIE CAPABLE OF ACCOMMODATING ANY SHAPE. ATTACHED TO THE RUBBER DIAPHRAGM IS A WEAR-PAD WHICH ACTS AS A BLANKHOLDER AND PROTECTS THE DIAPHRAGM.

SCENE 49.

tape 748, 03:24:51-03:25:02
zoom out, punch mounted on bed
of press

NARRATION (VO) :

A SINGLE TOOL, TYPICALLY A PUNCH, BUT IN SOME CASES A CAVITY DIE, IS MOUNTED TO A HYDRAULIC CYLINDER ON THE BED OF THE PRESS.

SCENE 50.

tape 747, 02:04:21-02:04:26
blank placed on lower
blankholder of press
tape 747, 02:04:35-02:04:40
forming chamber lowered

NARRATION (VO) :

A BLANK IS PLACED ON THE LOWER BLANKHOLDER OF THE RUBBER DIAPHRAGM FORMING PRESS. THE FORMING

tape 763, 00:17:43-00:17:56
ANI: rubber diaphragm forming
operation, punch moving upward
into the flexible die member,
shaping the sheet metal material
into final shape
CG, SUPER: 5,000 psi/345 bar
15,000 psi/1,034 bar

CHAMBER IS THEN LOWERED AND INITIAL PRESSURE IS
APPLIED. THE PUNCH MOVES UPWARD AND INTO THE
FLEXIBLE DIE MEMBER, SHAPING THE SHEET METAL
MATERIAL. TYPICAL PRESSURES FOR RUBBER DIAPHRAGM
FORMING RANGE FROM 5,000 'PSI', OR 345 'BAR' TO
15,000 'PSI', OR 1,034 'BAR'.

SCENE 51.
continue previous animation
tape 747, 02:04:52-02:04:59
rubber diaphragm forming
operation ending, press opening
showing finished part

NARRATION (VO) :
AFTER FORMING IS COMPLETED, PRESSURE IS RELEASED,
THE FORMING CHAMBER IS RAISED, AND THE PUNCH IS
STRIPPED FROM THE FINISHED PART.

--- TOUCH BLACK ---

SCENE 52.
tape 292, 01:13:46-01:14:08
zoom out, large-panel sheet
metal component being
conventionally stamped

NARRATION (VO) :
LARGE-PANEL SHEET METAL COMPONENTS, SUCH AS
AUTOMOBILE HOODS, ROOFS, DOORS, AND QUARTER
PANELS, HAVE MINIMAL BUCKLING STRENGTH AT THEIR
CENTERS. THIS IS DUE TO THE LOW LEVEL OF
DEFORMATION THAT OCCURS DURING THEIR MANUFACTURE,
WHICH RESULTS IN MINIMAL STRAIN HARDENING.

SCENE 53.
tape 293, 02:02:47-02:03:06
large-panel sheet metal
component being conventionally
stamped

NARRATION (VO) :
THIS DEFICIENCY CAN BE OVERCOME BY USING HIGHER
STRENGTH MATERIALS OR REINFORCING ELEMENTS, BOTH
OF WHICH CAN ADD COST AND WEIGHT TO A VEHICLE.

SCENE 54.
CG, SUPER: Active Hydro-
Mechanical Drawing
tape 752, 10:05:30-10:05:47
zoom out, active hydro-
mechanical drawing ending

NARRATION (VO) :
ACTIVE HYDRO-MECHANICAL DRAWING IS A PROCESS THAT
IS TYPICALLY USED IN FORMING LARGE SHEET METAL
PANELS, WHILE IMPROVING THEIR BUCKLING STRENGTH.

SCENE 55.

tape 752, 10:11:50-10:11:55
lower blankholder reservoir for
fluid, loop image if needed
tape 752, 10:28:07-10:28:18
top female die holding punch

NARRATION (VO) :

THE LOWER BLANKHOLDER IS A RESERVOIR THAT HOLDS
THE OIL-WATER EMULSION FLUID MEDIUM...,
AND THE TOP FEMALE DIE HOLDS THE PUNCH.

SCENE 56.

tape 752, 10:13:46-10:13:57
large-size blank placed over
empty reservoir
tape 763, 00:04:06-00:04:26
ANI: active hydro-mechanical
drawing operation, pressing
closing, blank clamped against
seal between female die and
blank holder

NARRATION (VO) :

A LARGE-SIZE BLANK IS PLACED OVER THE
RESERVOIR...,
AND AS THE PRESS IS CLOSED, CLAMPED ALL AROUND
WITH A WATER-TIGHT SEAL BETWEEN THE FEMALE DIE AND
THE BLANK HOLDER.

SCENE 57.

tape 763, 01:00:40-01:01:20
GRAPHIC: c.u. of part specific
gap
GRAPHIC: add scrolling arrow
showing part-specific gap
between blank and punch
tape 763, 00:04:37-00:04:48
continue previous animation,
fluid fills chamber, builds up
pressure, bulging the metal
slowly until the bulge rests
against the surface of the punch
tape 763, 00:20:49-00:20:59
ANI: c.u. fluid bulging the
metal slowly until the bulge
rests against the surface of the
punch

NARRATION (VO) :

AT THIS STAGE, A PART-SPECIFIC GAP EXISTS BETWEEN
THE CLAMPED BLANK AND THE PUNCH. AS SOON AS THE
BLANK-HOLDING FORCE HAS BUILT, THE FLUID IS
BROUGHT TO A DEFINED PRESSURE. THIS PRESSURE
CAUSES A CONTROLLED BULGING OF THE BLANK OVER ITS
ENTIRE SURFACE, RESULTING IN WORK HARDENING OF THE
WORKPIECE AND A SUBSTANTIAL IMPROVEMENT IN
BUCKLING STRENGTH OF THE PART. BULGING CONTINUES
UNTIL THE BLANK COMES TO REST AGAINST THE CENTER
OF THE PUNCH SURFACE.

SCENE 58.

tape 763, 00:05:14-00:05:26
continue previous animation,
punch lowered into the blank,
forming part against fluid
pressure

NARRATION (VO) :

AFTER THIS PRE-STRETCHING PROCESS, THE PUNCH IS
LOWERED INTO THE BLANK. THE SHEET METAL FLOWS
RATHER THAN RUBS AGAINST THE PUNCH AND FEMALE DIE
BY FLUID PRESSURE.

SCENE 59.

tape 752, 10:12:58-10:13:06

NARRATION (VO) :

operation ending, press opening,
dissolve into next shot
tape 752, 10:13:12-10:13:18
workers pulling part out of
active hydro-mechanical drawing
operation

BECAUSE THE BLANK IS FORMED AGAINST FLUID
PRESSURE, OPTIMUM QUALITY OF THE OUTER SKIN OF THE
FINISHED PART IS ENSURED.

SCENE 60.

tape 752, 10:18:36-10:19:00
part on press for active hydro-
mechanical drawing operation,
process started, dissolve into
next shot
tape 752, 10:19:20-10:19:30
punch coming down during active
hydro-mechanical drawing
operation

NARRATION (VO) :

ADVANTAGES OF THE ACTIVE HYDRO-MECHANICAL PROCESS,
IN ADDITION TO PART WEIGHT SAVINGS AND LACK OF A
NEED FOR REINFORCING ELEMENTS IN LARGE PANELS, IS
THE SAVINGS IN TOOLING COSTS, SINCE ONLY ONE DIE
HALF NEEDS TO BE MACHINED TO ACHIEVE THE REQUIRED
PART SHAPE.

--- TOUCH BLACK ---

SCENE 61.

tape 740, 01:18:56-01:19:04
part with many holes coming out
of hydroforming operation
tape 762, 11:07:30-11:07:37
laser drilling of hydroformed
part
tape 745, 05:07:36-05:07:45
post-hydroforming arc welding
operation
tape 742, 03:04:29-03:04:38
post-hydroforming use of
mechanical fasteners
tape 743, 04:22:45-04:22:51
post-hydroforming holemaking
operation
tape 759, 06:04:19-06:04:25
post-hydroforming sawing
operation
tape 745, 05:11:37-05:11:55
arc welding of hydroformed parts

NARRATION (VO) :

ALTHOUGH MANY SECONDARY OPERATIONS ARE PERFORMED
DURING THE HYDROFORMING PROCESS, POST-HYDROFORMING
OPERATIONS ARE NEEDED TO FINISH TUBULAR AND SHEET
METAL PARTS. COMMON POST-HYDROFORMING PROCESSING
INCLUDES:
ADDITIONAL HOLEMAKING...,
TRIMMING...,
AND JOINING OPERATIONS.

SCENE 62.

tape 762, 11:12:11-11:12:17
zoom out, laser drilling of
hydroformed part
tape 743, 04:24:21-04:24:30
post-hydroforming flow drilling
operation
tape 748, 03:10:55-03:11:10
post-hydroforming machining

NARRATION (VO) :

A NUMBER OF HOLEMAKING METHODS PRODUCE HOLES WHERE
HYDRO-PIERCING IS NOT POSSIBLE, THESE HOLEMAKING
METHODS INCLUDE:

operation producing hole,
dissolve into next shot
tape 748, 03:11:22-03:11:26
hole produced through machining
CG, SUPER: Conventional Drilling
Laser Drilling
Punching
Cutting
Machining

CONVENTIONAL DRILLING,
LASER DRILLING,
PUNCHING,
CUTTING,
AND MACHINING PROCESSES.

SCENE 63.

tape 741, 02:19:10-02:19:18
shearing of hydroformed parts
tape 762, 11:06:32-11:06:47
zoom out, lasers trimming of
hydroformed parts
tape 748, 03:19:51-03:20:01
post-hydroforming trimming die
being used
tape 749, 04:15:30-04:15:47
zoom in, machining of excess
material from hydroformed part
tape 759, 06:03:28-06:03:38
zoom out, sawing of hydroformed
part
tape 749, 04:17:11-04:17:19
zoom in, shearing of hydroformed
part

NARRATION (VO) :

TRIMMING PROCESSES REMOVE THE SURPLUS FORMING
MATERIAL FROM HYDROFORMED PARTS TO PRODUCE THE
DESIRED PART SHAPE AND SIZE. TRIMMING PROCESSES
INCLUDE THE USE OF:
CUTTING LASERS...,
TRIMMING DIES...,
MACHINING...,
SAWING...,
AND SHEARING OPERATIONS.

SCENE 64.

tape 745, 05:13:28-05:13:51
arc welding of hydroformed parts
tape 742, 03:03:50-03:03:57
mechanical fasteners used on
hydroformed part

NARRATION (VO) :

JOINING OPERATIONS ARE PERFORMED TO ASSEMBLE
HYDROFORMED COMPONENTS TO EXISTING STRUCTURAL
ASSEMBLIES. COMMON JOINING OPERATIONS INCLUDE THE
VARIOUS WELDING PROCESSES...,
AND THE USE OF MECHANICAL FASTENERS.

--- FADE TO BLACK ---

SCENE 65.

CG: Review
white text on black
tape 764, 01:17:44-01:21:13
peter carey narration
tape 63, 12:00:15-12:03:49
review music

MUSIC UP AND UNDER

NARRATION (VO) :

LET'S REVIEW THE MATERIAL CONTAINED IN THIS
VIDEOTAPE.

SCENE 66.

tape 759, 06:22:10-06:22:39

NARRATION (VO) :

hydroforming operation ending

HYDROFORMING PROCESSES USE FLUID PRESSURE APPLIED TO A BLANK TO FORM THE DESIRED COMPONENT SHAPE.

SCENE 67.

continue previous shot
tape 748, 03:03:33-03:03:42
sheet metal blank placed in hydroforming press

NARRATION (VO) :

THESE BLANKS CAN BE EITHER TUBULAR MATERIAL..., OR SHEET METAL MATERIAL.

SCENE 68.

tape 759, 06:16:13-06:16:20
tubular hydroforming blank placed on the lower tooling, dissolve into next shot
tape 759, 06:16:21-06:16:27
die closed over tooling
tape 763, 00:02:58-00:03:10
ANI: fluid pressure applied in tubular blank
tape 763, 00:05:14-00:05:26
ANI: fluid pressure applied in sheet metal blank, blank deforming into shape of tooling
tape 752, 10:06:32-10:06:45
zoom out, sheet metal hydroforming operation ending

NARRATION (VO) :

IN A TYPICAL HYDROFORMING OPERATING CYCLE, A BLANK IS PLACED ON THE LOWER TOOLING..., THEN THE PRESS IS CLOSED..., FLUID PRESSURE IS THEN APPLIED INTO THE TUBULAR SECTION..., OR ONTO ONE SIDE OF THE SHEET METAL BLANK..., THE MAGNITUDE OF PRESSURE IS HIGH ENOUGH TO CAUSE THE BLANK MATERIAL TO DEFORM PLASTICALLY, TAKING THE SHAPE OF THE TOOLING.

SCENE 69.

tape 758, 05:08:40-05:08:44
hydroforming operation, parts in press, press closed, dissolve into next shot
tape 758, 05:08:48-05:08:54
hydroforming of parts, dissolve into next shot
tape 758, 05:09:03-05:09:12
hydroforming operation, press opens with hydroformed parts
tape 751, 02:12:49-02:12:52
c.u. hydro-piercing punch activating, dissolve into next shot
tape 751, 02:11:27-02:11:34
part ejected from hydroforming die, showing piercing
tape 741, 02:19:23-02:19:30
hydroformed stamped part being trimmed

NARRATION (VO) :

THERE ARE SEVERAL ADVANTAGES TO HYDROFORMED COMPONENTS OVER CONVENTIONALLY MANUFACTURED PARTS: CONVENTIONALLY PRODUCED MULTI-COMPONENT PARTS CAN BE HYDROFORMED FROM A SINGLE BLANK, REDUCING PART COUNT AND POSSIBLY WEIGHT..., MOST, IF NOT ALL, FORMING AND PIERCING OPERATIONS CAN BE PERFORMED WITHIN A SINGLE HYDROFORMING SET-UP..., AND SCRAP RATES FOR HYDROFORMING CAN BE SIGNIFICANTLY LOWER THAN TRADITIONAL STAMPING SCRAP RATES.

SCENE 70.

tape 757, 00:12:01-00:12:07

tubular hydroforming operation
beginning, dissolve into next
shot

tape 757, 00:12:33-00:12:41

tubular hydroforming operation
ending

CG, SUPER: Tubular Hydroforming

tape 752, 10:03:34-10:03:50

sheet metal hydroforming
operation ending emphasizing
tooling

CG, SUPER: Sheet Metal

Hydroforming

NARRATION (VO) :

BECAUSE OF SPECIFIC PROCESS REQUIREMENTS,

HYDROFORMING OPERATIONS ARE TYPICALLY DEFINED AS

EITHER TUBULAR HYDROFORMING...,

OR SHEET METAL HYDROFORMING.

SCENE 71.

tape 759, 06:17:45-06:17:58

tubular hydroforming operation,
straight tube placed into die

tape 740, 01:02:58-01:03:04

tubular hydroforming operation,
bent tube placed into die

NARRATION (VO) :

TUBULAR HYDROFORMING BEGINS WITH THE PLACEMENT OF

STRAIGHT TUBES INTO THE DIE...,

BUT IS MORE COMMONLY BEGUN USING PREFORMED TUBES.

SCENE 72.

tape 740, 01:08:17-01:08:32

tube being bent on rotary draw
bending machine before
hydroforming

tape 750, 01:02:55-01:03:02

c.u. part bent in preforming die

tape 754, 01:22:35-01:22:47

tube being bent during the
hydroforming operation

NARRATION (VO) :

TUBE PREFORMING CAN BE DONE BEFORE HYDROFORMING

USING EITHER A ROTARY DRAW BENDING METHOD...,

AND/OR A PREFORMING DIE...,

PREFORMING ALSO CAN BE DONE DURING THE

HYDROFORMING OPERATION, WHICH IS REFERRED TO AS

HYDRO-BENDING.

SCENE 73.

tape 759, 06:27:03-06:27:12

low-pressure hydroforming
operation ending, dissolve into
next shot

tape 759, 06:27:19-06:27:26

low-pressure hydroforming
operation beginning

CG, SUPER: Low-Pressure

Hydroforming/LPH

tape 751, 02:05:42-02:05:53

high-pressure hydroforming
operation ending

CG, SUPER: High-Pressure

Hydroforming/HPH

tape 740, 01:28:22-01:28:29

NARRATION (VO) :

TUBULAR HYDROFORMING IS GENERALLY DIVIDED INTO

THREE CLASSIFICATIONS OR OPERATING TECHNIQUES:

LOW-PRESSURE HYDROFORMING, OR 'LPH'...,

HIGH-PRESSURE HYDROFORMING, OR 'HPH'...,

AND PRESSURE SEQUENCE HYDROFORMING, OR 'PSH'.

pressure sequence hydroforming
operation
CG, SUPER: Pressure Sequence
Hydroforming/PSH

SCENE 74.

tape 749, 04:10:32-04:10:38
sheet metal hydroforming
operation ending, part taken
out, dissolve into next shot
tape 749, 04:10:59-04:11:08
blank placed in press, cycle
started

NARRATION (VO) :

IN SHEET METAL HYDROFORMING, CONTROLLED METAL FLOW
DURING THE OPERATION MINIMIZES LOCALIZED STRESS
CONCENTRATIONS THAT MAY CAUSE WORKPIECE BUCKLING
OR WRINKLING.

SCENE 75.

tape 748, 03:01:31-03:01:34
rubber diaphragm forming
operation beginning, dissolve
into next shot
tape 748, 03:01:37-03:01:42
rubber diaphragm forming
operation ending
CG, SUPER: Rubber Diaphragm
Forming
tape 752, 10:09:03-10:09:12
zoom out, active hydro-
mechanical drawing operation
CG, SUPER: Active Hydro-
Mechanical Drawing

NARRATION (VO) :

THE COMMON METHODS OF HYDROFORMING SHEET METAL
MATERIAL INCLUDE:
RUBBER DIAPHRAGM FORMING...,
AND ACTIVE HYDRO-MECHANICAL DRAWING.

SCENE 76.

tape 740, 01:18:56-01:19:04
part with many holes coming out
of hydroforming operation
tape 751, 02:10:53-02:11:02
hydro-piercing operation
tape 762, 11:07:30-11:07:37
laser drilling of hydroformed
part
tape 745, 05:07:36-05:07:45
post-hydroforming arc welding
operation
tape 743, 04:22:45-04:22:51
post-hydroforming holemaking
operation
tape 759, 06:03:33-06:03:42
post-hydroforming sawing
operation
tape 745, 05:11:37-05:11:55
arc welding of hydroformed parts

NARRATION (VO) :

ALTHOUGH MANY SECONDARY OPERATIONS ARE PERFORMED
DURING THE HYDROFORMING PROCESS, SUCH AS HYDRO-
PIERCING, POST-HYDROFORMING OPERATIONS ARE NEEDED
TO FINISH TUBULAR AND SHEET METAL PARTS. COMMON
POST-HYDROFORMING PROCESSING INCLUDES:
ADDITIONAL HOLEMaking...,
TRIMMING...,
AND JOINING OPERATIONS.

--- FADE TO BLACK ---

SCENE 77.
CG, ROLL: credits

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white text on black, fade up
mid-screen

tape 715, 01:01:10-01:01:50

GRAPHIC: AFFT logo

the Society of Manufacturing Engineers

Executive Producer:

Steven R. Bollinger

Producer/Director/Cameraman:

Jerome T. Cook

Written By:

Richard G. Green,

Summit Editorial Enterprises

Additional Hydroforming Reference Materials

Provided By:

Harry Singh,

HydroDynamic Technologies, Inc.

Graphics By:

Dennis Summers,

Quantum Dance Works

Jerome T. Cook

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Technical & Editorial Consulting:

Rudi Schubert,
Schuler Incorporated
Zeev Zimerman, PhD, PE

Production Assistance Provided By:

Patrick Fitzpatrick
Aimee Longato
Lance Rosol

Video Editing:

Communicore

SCENE 78.
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 79.
tape 40, 01:00:00-01:00:12
SME logo, with music
CG, SUPER: www.sme.org