

**FUNDAMENTAL MANUFACTURING PROCESSES**

Workholding - WH

SCENE 1.

**FMP01A**, CGS: FBI warning  
text centered on black to transparent  
gradient  
**FMP BKG**, motion background

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SCENE 2.

continue motion background  
**FMP02A**, CGS: DRL screen  
text centered on black to transparent  
gradient

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SCENE 3.

continue motion background  
**FMP03A**, CGS: disclaimer  
white text, centered on background

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

SCENE 4.

**FMP SME**, SME logo open, with music

SCENE 5.

**FMP05A**, FMP open, with music  
**WH05B**, edited peter carey narration  
**WH05C**, peter carey rerecorded narration

**MUSIC UP AND UNDER**

**NARRATION (VO) :**

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

SCENE 6.

continue FMP open  
**WH06A**, CGS: Workholding

**NARRATION (VO) :**

white text, centered on background  
**FTD06B**, blue background  
**FTD06C**, sound slug

SCENE 7.

**WH07A, SME4303, 03:12:12:00-03:12:22:00**  
zoom out, part being held, machined

SCENE 8.

**WH08A, SME4315, 09:19:03:00-09:19:22:00**  
zoom out, work clamped, being machined  
**WH08B, SME4383, 14:51:00:00-14:51:06:00**  
zoom out, clamp  
**WH08C, SME4302, 01:54:48:00-01:55:00:00**  
part clamped to vise  
**WH08D, SME4356, 09:41:00:00-09:41:10:00**  
tombstone  
**WH08E, SME4350, 02:43:08:00-02:43:18:00**  
zoom out, chuck, rotating large workpiece

SCENE 9.

**WH09A, SME4317, 11:04:55:00-11:05:15:00**  
zoom in, part being secured  
**WH09B, CGS: Which Surfaces/Holes are**  
Designated as Reference  
Measurement Surfaces/Datums  
**WH09C, SME4317, 11:11:30:00-11:12:13:00**  
part being machined using two cutting  
tools, edit at multiple points  
**WH09D, CGS: Which Surfaces can be Machined**  
in a Setup  
**WH09E, CGS: Accuracy of the Machining**  
Process  
**WH09F, CGS: Allowable Cutting Forces/  
Cutting Feeds & Speeds**  
**WH09G, CGS: Cutting Tool Path/Tool's Size  
& Shape**

THIS PROGRAM IS AN INTRODUCTION TO  
WORKHOLDING FOR MILLING AND TURNING.

**NARRATION (VO) :**

WORKHOLDING IS A FUNDAMENTAL ISSUE WHEN  
PERFORMING ANY MACHINING PROCESS.

**NARRATION (VO) :**

WORKHOLDING TOOLS INCLUDE ANY DEVICE  
USED TO GRIP A WORKPIECE WHILE IT IS  
MACHINED IN A MACHINE TOOL. IT INCLUDES  
CLAMPS...,  
VISES...,  
FIXTURES...,  
CHUCKS, AND MORE.

**NARRATION (VO) :**

THE DECISION ON HOW TO HOLD A PART  
INFLUENCES A NUMBER OF FACTORS IN THE  
OVERALL MILLING OR TURNING PROCESS,  
INCLUDING:  
WHICH SURFACES OR HOLES ARE DESIGNATED  
AS REFERENCE MEASUREMENT SURFACES, OR  
DATUMS...,  
WHICH SURFACES CAN BE MACHINED IN A  
SINGLE SETUP...,  
THE ACCURACY OF THE MACHINING  
PROCESS...,  
THE ALLOWABLE CUTTING FORCES - AND  
POTENTIALLY THE CUTTING FEEDS &

SPEEDS...,

AND THE CUTTING TOOL PATH, AND SOMETIMES  
THE TOOL'S SIZE AND SHAPE.

SCENE 10.

**WH10A, SME4026, 11:29:09:00-11:29:20:00**  
zoom out, worker at machine while running  
**WH10B, SME4026, 11:46:50:00-11:47:26:00**  
worker unloading, loading workpiece,  
closing door of machine  
**WH10C, SME4026, 11:48:05:00-11:48:17:00**  
worker gaging same workpiece  
**WH10D, SME4025, 10:18:00:00-10:18:20:00**  
unloading, loading workpiece, edit at  
multiple points  
**WH10E, SME4091, 07:24:36:00-07:24:43:00**  
milling of transmission housing  
**WH10F, SME4091, 07:26:20:00-07:27:02:00**  
drilling and tapping of transmission  
housing, edit at multiple points  
**WH10G, SME4355, 07:20:35:00-07:20:57:00**  
zoom out, milling various parts loaded in  
chuck on machine table

**NARRATION (VO) :**

WORKHOLDING DEVICES MUST ALSO SUIT  
PRODUCTION DEMANDS IN A LEAN  
MANUFACTURING ENVIRONMENT. THE ULTIMATE  
GOAL BEING THE MINIMIZATION OF TIME AN  
OPERATOR SPENDS MANIPULATING THE  
WORKHOLDING, LEAVING HIM FREE TO TEND  
OTHER MACHINES OR HIGHER-VALUE  
OPERATIONS.  
PARTS SHOULD BE EASY TO UNLOAD...,  
AND LOAD...,  
THE WORKHOLDING MUST PERMIT ACCESS OF  
VARIOUS CUTTING TOOLS TO THE WORKPIECE,  
SO THAT MULTIPLE OPERATIONS CAN BE  
PERFORMED IN A SINGLE CLAMPING...,  
AND WORKHOLDING SHOULD ALLOW OPTIMUM USE  
OF THE MACHINE TOOL'S MACHINING  
CAPACITY, SO THAT AS MANY PARTS AS  
POSSIBLE CAN BE MACHINED IN ONE SETUP.

SCENE 11.

**WH11A, SME2638, 01:16:02:00-01:16:09:00**  
workholding being setup  
**WH11B, SME2638, 01:14:36:00-01:14:43:00**  
workholding being torn down  
**WH11C, web pages with standard order**  
workholding tools, 5 pages  
**WH11D, web pages with standard order**  
workholding tools, 4 pages

**NARRATION (VO) :**

MOREOVER, THE WORKHOLDING SETUP...,  
AND TEARDOWN PROCESS SHOULD BE SIMPLE  
AND FAST...,  
AND, TO MINIMIZE WORKHOLDING COSTS,  
STANDARD ORDER ITEMS SHOULD BE USED WHEN

POSSIBLE.

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SCENE 12.

**WH12A**, CGS: Principles of Workholding  
white text, centered on background  
**FMP BKG**, motion background

SCENE 13.

**WH13A**, part on blue background  
**WH13B**, part with datum plane highlighted  
**WH13C**, part with datum lines highlighted  
**WH13D**, part with datum hole highlighted  
**WH13E**, CGS: Datums

**NARRATION (VO) :**

A MACHINED PART HAS CERTAIN PLANES,  
LINES, AND/OR HOLES FROM WHICH OTHER  
POINTS ARE MEASURED. THESE REFERENCE  
POINTS OR PLANES ARE CALLED DATUMS.

SCENE 14.

**WH14A, SME2638, 01:18:12:00-01:18:22:00**  
part released from workholding, freeze  
last frame  
**WH14B, SME2638, 01:18:23:00-01:18:35:00**  
new part secured onto workholding  
**WH14C, SME4026, 11:55:59:00-11:56:10:00**  
alternate shot, zoom out, multiples of the  
same part

**NARRATION (VO) :**

TO CORRECTLY MACHINE A PART, IT MUST BE  
HELD IN A SETUP THAT GUARANTEES A  
DEFINITE LOCATION, OR POSITION AND  
ORIENTATION IN SPACE, WITH RESPECT TO  
THE PART'S DATUM POINTS OR SURFACES.  
THIS MUST BE REPEATABLE, PART-AFTER-  
PART.

SCENE 15.

**WH15A, SME4132, 03:22:12:00-03:22:43:00**  
clamped part being machined

**NARRATION (VO) :**

SECONDLY, THE WORKHOLDING DEVICE MUST  
HOLD THE PART SECURELY IN POSITION WHILE  
CUTTING FORCES, VIBRATIONS, CENTRIFUGAL  
FORCE, AND GRAVITY ACT TO DISLODGE IT.

SCENE 16.

**WH16A, SME2638, 01:04:38:00-01:05:10:00**  
clamped part being machined

**NARRATION (VO) :**

IN THEORY, THE LOCATION AND CLAMPING OF  
WORKPIECES ARE CONSIDERED SEPARATE  
ISSUES. BUT IN WORKHOLDING PRACTICE,

LOCATING AND CLAMPING ARE INTEGRATED AS PART OF THE SAME PROCESS.

SCENE 17.

**WH17A, SME4315, 09:30:27:00-09:30:53:00**  
zoom out, machining part  
**WH17B, SME2648, 21:02:18:00-21:02:30:00**  
over tightening work in vise

**NARRATION (VO) :**

THE HOLDING ACTION ENSURES THE WORKPIECE IS STABLE FOR MACHINING, ONCE LOCATED. IF IT IS NOT RESTRAINED ADEQUATELY, THE WORKPIECE WILL MOVE AND BECOME SCRAP. CONVERSELY, THE CLAMPING FORCE MUST NOT BE INAPPROPRIATELY EXCESSIVE, SO AS TO DISTORT, GOUGE, OR BREAK THE WORKPIECE.

--- TOUCH BLACK ---

SCENE 18.

**WH18A, SME4383, 14:20:18:00-14:20:27:00**  
rectangular workpiece secured on fixture  
**WH18B, CGS: Six Degrees of Freedom**  
**WH18C, solid object on blue background**  
**WH18D, X axis appears**  
**WH18E, Y axis appears**  
**WH18F, Z axis appears**  
**WH18G, clockwise rotation of axes appears**  
**WH18H, counterclockwise rotation of axes appears**

**NARRATION (VO) :**

WORKHOLDING STARTS FROM VISUALIZING THE COORDINATE SYSTEM REPRESENTING A SOLID OBJECT IN SPACE, KNOWN AS THE SIX DEGREES OF FREEDOM. THESE SIX COORDINATES CONSIST OF THE PLUS AND MINUS MOVEMENT IN THE "X"... , "Y"... , AND "Z" AXES, AND THE CLOCKWISE... , AND COUNTERCLOCKWISE ROTATION AROUND EACH OF THESE THREE AXES.

SCENE 19.

continue previous shot  
**WH18G, counterclockwise vanishes**  
**WH18F, clockwise vanishes**  
**WH18E, Z axis disappears**  
**WH18D, Y axis disappears**  
**WH18C, X axis disappears, solid object on blue background**

**NARRATION (VO) :**

THERE ARE TWELVE DIRECTIONS OF MOVEMENT THAT MAKE-UP THESE SIX DEGREES OF FREEDOM. TO ACCURATELY LOCATE A

WORKPIECE FOR MACHINING, IT MUST BE SECURED TO RESTRICT MOVEMENT IN THESE TWELVE DIRECTIONS.

SCENE 20.

**WH20A, SME4395, 05:15:27:00-05:15:42:00**  
zoom out, part located on threaded locator  
**WH20B, SME4383, 14:42:00:00-14:42:15:00**  
alternate shot, part located on circular surface  
**WH20C, CGS: Circular**  
                  Irregular  
                  Plane

**NARRATION (VO) :**

LOCATING MAY BE DONE FROM CIRCULAR, IRREGULAR OR PLANE SURFACES.

SCENE 21.

**WH21A, SME4394, 04:32:02:00-04:32:23:00**  
zoom out, rectangular parts being secured  
**WH21B, six locators on blue background**  
**WH21C, translucent part faces over locators**  
**WH21D, solid part resting on locators**  
**WH18H, 12 directions of movement**  
**WH21E, remaining 3 directions of movement not cancelled with locators**  
**WH21F, CGS: 3-2-1 Locational Method**

**NARRATION (VO) :**

THE 3-2-1 LOCATIONAL METHOD IS SUITED FOR RECTANGULAR PARTS LOCATED BY THEIR OUTER EDGES. WITH THIS METHOD, SIX POINTS OF CONTACT, OR LOCATORS, ON THE FACES OF AN OBJECT COLLECTIVELY CANCEL NINE OF THE TWELVE DIRECTIONS OF MOVEMENT.

SCENE 22.

**WH21B, six locators on blue background**  
**WH22A, 3 primary locators highlighted**  
**WH22B, CGS: 3 Primary Locators**  
**WH22C, 2 secondary locators highlighted**  
**WH22D, CGS: 2 Secondary Locators**  
**WH22E, 1 tertiary locator highlighted**  
**WH22F, CGS: 1 Tertiary Locator**

**NARRATION (VO) :**

THESE SIX CONTACT POINTS INCLUDE: THREE PRIMARY LOCATORS..., TWO SECONDARY LOCATORS..., AND A SINGLE TERTIARY LOCATOR.

SCENE 23.

**WH22B, CGS: 3 Primary Locators**  
**WH23B, 3 primary locators on blue background**  
**WH23C, translucent plane over 3 locators**  
**WH18H, 12 directions of movement**  
**WH23D, -Z axis restrained**  
**WH23E, X rotary axes restrained**  
**WH23F, Y rotary axes restrained**

**NARRATION (VO) :**

THE THREE PRIMARY LOCATORS ESTABLISH THE PLANE UPON WHICH THE PART RESTS. THESE LOCATORS RESTRAIN FIVE OF THE TWELVE DIRECTIONS OF MOVEMENT: THE DOWN DIRECTION OR MINUS "Z" AXIS, AND THE

CLOCKWISE AND COUNTERCLOCKWISE ROTARY  
MOTIONS AROUND THE "X" AND "Y" AXES.

SCENE 24.

**WH22D**, CGS: 2 Secondary Locators  
**WH24B**, 2 secondary locators on blue  
background  
**WH24C**, translucent plane over 2 locators  
**WH23F**, 5 of 12 directions restrained  
**WH24D**, +Y axis restrained  
**WH24E**, Z rotary axes restrained

**NARRATION (VO) :**

THE TWO SECONDARY LOCATORS ARE 90  
DEGREES TO THE PRIMARIES, AND IN THE  
ESTABLISHED PLANE. THESE LOCATORS  
RESTRICT THREE ADDITIONAL DIRECTIONS OF  
MOVEMENT: THE PLUS "Y" AXIS, AND THE  
CLOCKWISE AND COUNTERCLOCKWISE ROTARY  
MOTIONS AROUND THE "Z" AXIS.

SCENE 25.

**WH22F**, CGS: 1 Tertiary Locator  
**WH25B**, single tertiary locator on blue  
background  
**WH25C**, translucent plane over tertiary  
locator  
**WH24E**, 8 of 12 movements restrained  
**WH25D**, -X axis is restrained

**NARRATION (VO) :**

THE FINAL, TERTIARY LOCATOR IS FOUND 90  
DEGREES TO THE SECONDARY LOCATORS. IT  
RESTRICTS THE MINUS "X" AXIS. TOGETHER,  
THESE SIX LOCATORS ABSORB THE PRIMARY  
MACHINING FORCES.

SCENE 26.

**WH26A**, **SME4024**, **09:20:56:00-09:21:11:00**  
rectangular parts secured for machining  
**WH25D**, 9 of 12 directions restrained  
**WH26B**, +X axis restrained  
**WH26C**, +Z axis restrained  
**WH21D**, block of steel, all directions of  
movement restrained

**NARRATION (VO) :**

WHEN A CLAMPING DEVICE IS ADDED, THE  
THREE AXES THAT REMAIN -- THE PLUS "X",  
THE PLUS "Z", AND THE MINUS "Y" AXES,  
ARE SECURED FOR MACHINING.

SCENE 27.

**WH21C**, translucent part faces over  
locators  
**WH27A**, additional locator added to primary  
locator set  
**WH27B**, additional locator added to  
secondary locator set  
**WH27C**, additional locator added to  
tertiary set

**NARRATION (VO) :**

ADDING ADDITIONAL, REDUNDANT LOCATORS  
ONLY RISKS MAGNIFYING ANY WORKPIECE  
VARIATIONS, COMPROMISING MACHINING  
ACCURACY, AS WELL AS INCREASING

WORKHOLDING COSTS.

--- TOUCH BLACK ---

SCENE 28.

**WH28A, SME4094, 09:13:00:00-09:14:10:00**  
parts being machined using various cutting  
tools, edit at various points  
**WH28B, SME4379, 10:55:21:00-10:55:34:00**  
zoom out, part being machined,

**NARRATION (VO) :**

FOR OPTIMUM ACCURACY AND PRODUCTIVITY,  
THE WORKHOLDING SHOULD ALLOW AS MANY  
OPERATIONS AS POSSIBLE TO BE DONE IN A  
SINGLE CLAMPING. RECLAMPING OR  
RECHUCKING HAVE TWO NEGATIVE IMPACTS.

SCENE 29.

**WH29A, SME4379, 10:53:02:00-10:53:10:00**  
part removed from first operation  
**WH29B, SME4379, 10:51:42:00-10:51:54:00**  
part moved to second location  
**WH29C, SME4380, 11:07:41:00-11:07:55:00**  
zoom out, part machined in a different  
location,  
**WH29D, SME4380, 11:17:50:00-11:18:00:00**  
zoom in, back of part clamped into fixture

**NARRATION (VO) :**

FIRST, WHEN THE WORKPIECE IS MOVED, THE  
LOCATION OF THE WORKPIECE IN RELATION TO  
THE MACHINE TOOL IS LOST. THAT  
COMPROMISES THE ACCURACY OF THE PART.  
SECONDLY, THE TIME REQUIRED TO SET UP A  
PART FOR MACHINING IS "NON-VALUE-ADDED  
TIME" -- ADDING COSTS AND WASTE TO AN  
OPERATION WITH EACH UNCLAMP/CLAMP CYCLE.

SCENE 30.

**WH30A, SME4120, 10:12:15:00-10:13:07:00**  
machined part being reclamped  
**WH30B, CGS: Datum Surfaces must be**  
Machined First  
A Through-Hole has Steps on  
Both Sides  
A Part has Blind Holes on  
Opposite Sides

**NARRATION (VO) :**

ALTHOUGH A SINGLE CLAMPING CYCLE IS  
IDEAL, TWO OR MORE CLAMPINGS OR  
CHUCKINGS MAY BE REQUIRED WHEN:  
DATUM SURFACES MUST BE MACHINED  
FIRST...,  
OR A THROUGH-HOLE HAS STEPS ON BOTH  
SIDES...,  
OR A PART HAS BLIND HOLES ON OPPOSITE  
SIDES.



SCENE 31.

**WH31A, SME4022, 07:18:20:00-07:19:06:00**  
intense rough milling  
**WH31B, SME4022, 07:21:40:00-07:22:16:00**  
intense rough milling  
**WH31C, SME4359, 11:39:04:00-11:39:24:00**  
rough milling

**NARRATION (VO) :**

ACCURACY CAN ALSO BE AFFECTED BY PART DEFLECTION, DEPENDING ON THE PART GEOMETRY AND CUTTING OPERATIONS. SO THE WORKHOLDING MUST GRIP THE WORKPIECE STRONGLY ENOUGH TO PREVENT PARTS DEFLECTING FROM THE CUTTING FORCES OF MACHINING. ACCORDINGLY, THE WORKHOLDING CAN INFLUENCE WHAT SPEEDS AND FEEDS ARE POSSIBLE IN A MACHINING PROCESS.

SCENE 32.

**WH32A, SME4394, 04:25:30:00-04:25:53:00**  
zoom out, parts mounted to tombstone being machined  
**WH32B, SME4383, 14:11:47:00-14:12:05:00**  
zoom in, small cluster of parts mounted to tombstone

**NARRATION (VO) :**

THE CHOICE OF WORKHOLDING ALSO INFLUENCES WHAT CUTTING TOOL PATH CAN BE PROGRAMMED INTO A CNC MACHINE TOOL. AND HIGHLY CLUSTERED PART SETUPS MAY LIMIT THE SIZE AND SHAPE OF THE CUTTING TOOLS THAT CAN BE USED.

SCENE 33.

**WH33A, SME4352, 04:10:46:00-04:11:10:00**  
zoom in, multiple parts being machined  
**WH33B, SME4352, 04:16:15:00-04:16:30:00**  
c.u., multiple parts being drilled  
**WH33C, SME4352, 04:43:42:00-04:43:53:00**  
c.u., multiple parts being tapped  
**WH33D, SME4352, 04:44:00:00-04:44:15:00**  
wide, multiple parts being rotated and milled

**NARRATION (VO) :**

WHEN MULTIPLE PARTS ARE MOUNTED AND MACHINED IN A SINGLE SET-UP, TIME AND COST SAVINGS CAN BE SIGNIFICANT. THE AVERAGE TIME PER PART FOR LOADING AND UNLOADING MAY BE REDUCED. AND SINCE EACH CUTTING-TOOL MACHINES MULTIPLE PARTS BEFORE BEING CHANGED, THE AVERAGE TIME FOR EACH CUTTING-TOOL CHANGE IS REDUCED IN THE PIECE COST. MULTI-PART SETUPS

ALLOW THESE SAVINGS UP TO THE POINT AT WHICH THEY ARE OFFSET BY INCREASED FIXTURE COSTS.

--- FADE TO BLACK ---

SCENE 34.

**WH34A**, CGS: Milling & Machining Center  
Workholding  
white text, centered on background  
**FMP BKG**, motion background

SCENE 35.

**WH35A**, **SME2638**, **01:11:42:00-01:11:51:00**  
multiple clamping on machining center  
**WH35B**, **SME4303**, **03:21:27:00-03:21:48:00**  
zoom out, milling large support  
**WH35C**, **SME4395**, **05:10:25:00-05:10:52:00**  
zoom out, parts placed in fixtures,  
pneumatic clamping actuated, doors closed  
for machining  
**WH35D**, **SME4374**, **04:38:33:00-04:38:47:00**  
dedicated fixture  
**WH35E**, **SME4305**, **05:05:00:00-05:05:30:00**  
zoom out, milling with clamping of large  
stamping die base on machining center  
table

**NARRATION (VO) :**

WORKHOLDING FOR MILLING SHOULD BE MATCHED TO THE PRODUCTION LEVEL. FOR SMALL-LOT PRODUCTION ON MILLING MACHINES, THE SIMPLEST MANUAL CLAMPS OR VISES ARE USED..., FOR MEDIUM-LOT PRODUCTION ON MACHINING CENTERS, QUICK-ACTING SINGLE AND MULTIPLE CLAMPING DEVICES ARE USED. IF VOLUME WARRANTS IT, HYDRAULICALLY- OR PNEUMATICALLY-ACTUATED CLAMPS CAN BE USED FOR THE FASTEST CLAMPING..., OR FOR MASS-PRODUCTION OF A UNIQUE PART, DEDICATED FIXTURING CAN BE BUILT.

--- TOUCH BLACK ---

SCENE 36.

**WH36A**, **SME4367**, **19:44:38:00-19:45:00:00**  
zoom out, clamps holding mold half during  
milling  
**WH36B**, **SME4367**, **19:50:07:00-19:50:22:00**  
clamps holding work during milling

**NARRATION (VO) :**

MANUALLY OPERATED CLAMPS ARE THE SIMPLEST WORKHOLDING DEVICE FOR MILLING. CLAMPING MUST BE STRONG SINCE THE CUTTING FORCES CHANGE DIRECTIONS AS THE

MILLING CUTTER ENTERS AND EXITS THE  
PART.

SCENE 37.

**WH37A, SME2638, 01:15:17:00-01:15:32:00**  
loading/securing workpieces with clamps

**NARRATION (VO) :**

CLAMPS MUST ALSO ACT QUICKLY FOR FAST  
LOADING AND UNLOADING, AND NOT DAMAGE  
THE WORKPIECE.

SCENE 38.

continue previous shot  
**WH38A, SME4363, 15:30:48:00-15:30:54:00**  
zoom out, strap clamp set up  
**WH38B, SME2645, 04:26:56:00-04:27:03:00**  
cam clamp

**NARRATION (VO) :**

THERE ARE MANY BASIC CLAMP TYPES, SOME  
ARE:  
THE STRAP CLAMP...,  
AND THE CAM CLAMP.

SCENE 39.

**WH39A, SME2645, 04:18:03:00-04:18:15:00**  
toggle clamp used in machining  
**WH39B, SME2639, 02:13:23:00-02:13:33:00**  
hold-down toggle clamp, clamping

**NARRATION (VO) :**

TOGGLE-ACTION CLAMPS HAVE AN EXCELLENT  
RATIO OF HOLDING FORCE TO APPLICATION  
FORCE. THEY WORK QUICKLY, AND HAVE A  
POSITIVE LOCKING ACTION. THE MOST  
POPULAR TOGGLE CLAMP IS THE HOLD-DOWN  
DESIGN, WHICH HOLDS THE PART WITH A  
DOWNWARD CLAMPING ACTION.

SCENE 40.

continue previous shot  
**WH40A, still, push/pull clamp**  
**WH40B, still, latch clamp**

**NARRATION (VO) :**

OTHER TYPES OF TOGGLE CLAMPS INCLUDE THE  
PUSH/PULL CLAMP...,  
AND THE LATCH CLAMP.

SCENE 41.

**WH41A, SME4024, 09:05:20:00-09:05:51:00**  
multiple vises being secured  
**WH41B, SME2645, 04:13:12:00-04:13:20:00**  
odd shaped part secured in vise  
**WH41C, SME2645, 04:09:53:00-04:10:02:00**  
alternate shot, odd shaped part secured in  
vise

**NARRATION (VO) :**

VICES CLAMP MANUALLY OR AUTOMATICALLY,  
AND CAN BE CONSTRUCTED TO HOLD A GREAT  
MANY SHAPES IN MANY WAYS. ONE VARIATION

**WH41D, SME4394, 04:49:07:00-04:49:33:00**  
multiple three jaw vises with parts  
removed

HAS A FIXED CENTER JAW AND TWO MOVING  
OUTER JAWS--TO HOLD TWO OR MORE PARTS IN  
LESS SPACE THAN TWO SEPARATE VISES.

SCENE 42.

**WH42A, SME4363, 15:41:55:00-15:42:11:00**  
swivel base vise being rotated

**NARRATION (VO) :**

SWIVEL OR TILTING BASES ALLOW THE VISE  
AND WORK TO BE SET AT AN ACCURATE  
ANGULAR POSITION RELATIVE TO THE MACHINE  
AXES.

SCENE 43.

**WH43A, SME4383, 14:32:11:00-14:32:32:00**  
zoom in, multiple vises holding long parts  
**WH43B, SME2645, 04:23:10:00-04:23:18:00**  
alternate shot, two vises holding long  
part

**NARRATION (VO) :**

MULTIPLE VISES CAN BE USED TO EXTEND THE  
RANGE OF WHAT MAY BE HELD--SUCH AS LONG  
PARTS.

SCENE 44.

**WH44A, SME4356, 09:43:11:00-09:43:24:00**  
setting up workholding on column  
**WH44B, SME4356, 09:44:38:00-09:44:56:00**  
alternate shot, zoom out, plate clamped to  
column  
**WH44C, SME2638, 01:10:50:00-01:10:58:00**  
workholding indexing in machining center

**NARRATION (VO) :**

TO MINIMIZE SETUP TIME ON MACHINING  
CENTERS, WORKHOLDING MAY BE ARRANGED  
AROUND A CUBE OR COLUMN,  
OR ON AN INDEXER OR ROTARY TABLE.

SCENE 45.

**WH45A, SME4394, 04:05:50:00-04:06:10:00**  
zoom in, parts secured on tombstone,  
rotated, parts removed  
**WH45B, SME4394, 04:02:41:00-04:03:16:00**  
alternate shot, setting up parts on  
tombstone

**NARRATION (VO) :**

PARTS MAY ALSO BE HELD ON TWO, THREE, OR  
FOUR SIDES OF A TOMBSTONE OR INDEXER,  
WITH IDENTICAL OR DIFFERENT WORKPIECES  
CLAMPED ON DIFFERENT SIDES.

SCENE 46.

**WH46A, SME4394, 04:21:02:00-04:21:19:00**  
multiple parts clamped on tombstone being  
machined

**NARRATION (VO) :**

MULTIPLE CLAMPS HOLD SMALL WORKPIECES IN  
POSITION AS THEY MACHINED ONE AFTER THE  
OTHER.

SCENE 47.

**WH47A, SME2646, 01:01:39:00-01:01:51:00**  
tombstone with chucks

**NARRATION (VO) :**

OR MULTIPLE CHUCKS CAN BE USED ON  
PALLETS AND TOMBSTONES TO HOLD ROUND  
PARTS.

SCENE 48.

**WH48A, SME4030, 17:04:46:00-17:05:01:00**  
zoom out, part indexing to new side using  
rotary table  
**WH48B, SME4026, 11:35:41:00-11:35:48:00**  
rotary table moving  
**WH48C, SME4351, 03:15:43:00-03:16:04:00**  
alternate shot, rotary table indexing part

**NARRATION (VO) :**

A ROTARY TABLE ALLOWS FOUR SIDES OF A  
WORKPIECE TO BE MACHINED IN ONE SETUP,  
AND ALLOWS THE MACHINING OF HOLES AND  
SURFACES AT ODD ANGLES. ROTARY TABLES  
ARE OF TWO TYPES:

SCENE 49.

**WH49A, SME4386, 18:48:41:00-18:48:59:00**  
part machined, rotary table indexing to  
new position  
**WH49B, SME4018, 02:20:25:00-02:20:45:00**  
zoom out, cutter/work moving

**NARRATION (VO) :**

THERE ARE INDEXING TABLES WHICH QUICKLY  
INDEX TO A FIXED POSITION OF ANGULAR  
ROTATION AND LOCK IN THAT POSITION FOR  
MACHINING...,  
AND THERE ARE "FULL" ROTARY TABLES WHICH  
TRAVERSE DURING CUTTING TO GENERATE  
SHAPES.

--- TOUCH BLACK ---

SCENE 50.

**WH50A, SME4315, 09:47:14:00-09:47:34:00**  
pan, modular fixturing post element

**NARRATION (VO) :**

OFTEN FIXTURES MAY BE REQUIRED FOR ODD-  
SHAPED OR SPECIALIZED PARTS.  
FORTUNATELY, MODULAR FIXTURING SYSTEMS  
CAN BE BUILT QUICKLY FROM A KIT OF  
VARIOUS COMPONENTS. THIS CUTS ASSEMBLY  
TIME WHILE MAXIMIZING FLEXIBILITY.

SCENE 51.

**WH51A, SME4315, 09:03:14:00-09:04:07:00**

cad screen build of modular fixturing  
elements, multiple cuts

**WH51B, CGS:** Base Plates

Supports

Locators

Clamps

**NARRATION (VO) :**

STANDARD INTERCHANGEABLE FIXTURING

COMPONENTS INCLUDE:

BASE PLATES,

SUPPORTS,

LOCATORS,

AND CLAMPS.

SCENE 52.

**WH52A, SME4315, 09:13:53:00-09:14:05:00**

zoom out, locating holes on modular  
fixture

**WH52B, still, zoom out, t-slot modular  
fixture with baseplate, clamps, angle  
plate, parts**

**WH52C, DV movie, zoom out, t-slot modular  
fixture with baseplate, clamps, angle  
plate, parts**

**NARRATION (VO) :**

MODULAR SYSTEMS START FROM A PATTERN OF

LOCATING DOWEL HOLES AND TAPPED HOLES,

OR FROM CONVENTIONAL T-SLOTS.

SCENE 53.

continue previous shot

**NARRATION (VO) :**

A T-SLOT-BASED SYSTEM STARTS WITH T-

SLOTTED BASEPLATES.

SCENE 54.

continue previous shot

**NARRATION (VO) :**

FIXTURE ELEMENTS LIKE CLAMPS ARE

ATTACHED TO THE BASE PLATE, ANGLE PLATE,

AND SO ON, TO CREATE THE FIXTURE.

SCENE 55.

continue previous shot

**WH55A, still, zoom in, t-slot modular  
fixture**

**WH55B, DV movie, zoom in, t-slot modular  
fixture**

**NARRATION (VO) :**

LIKE T-SLOTTED MACHINE TABLES, THE T-

SLOT SYSTEM HAS ONE MAJOR DISADVANTAGE -

- IT LACKS EXACT FIXED REFERENCES IN THE

'X' AND 'Y' AXES. TIME IS WASTED WHEN

LOCATING AND RECONSTRUCTING PREVIOUS

SETUPS.

SCENE 56.

**WH56A, SME4315, 09:47:48:00-09:48:03:00**  
zoom out, modular fixture with clamp

**NARRATION (VO) :**

PRECISION DOWEL-PIN-BASED MODULAR  
FIXTURING SYSTEMS DO ASSURE THE EXACT  
POSITION OF EACH FIXTURE ELEMENT.

SCENE 57.

**WH57A, SME4315, 09:14:59:00-09:15:09:00**  
pan fixture with part

**NARRATION (VO) :**

ITS DISADVANTAGE IS THAT THE DOWEL PIN  
LAYOUT MAY RESTRICT THE LOCATION OF  
CLAMPING DEVICES.

--- TOUCH BLACK ---

SCENE 58.

**WH58A, SME4356, 09:31:31:00-09:31:52:00**  
swapping tombstones  
**WH58B, SME4356, 09:34:48:00-09:35:16:00**  
part being milled  
**WH58C, SME4306, 06:31:39:00-06:31:51:00**  
part set up on tombstone  
**WH58D, SME4356, 09:45:38:00-09:45:49:00**  
alternate shot, zoom in, new part on  
tombstone

**NARRATION (VO) :**

MANY HORIZONTAL MACHINING CENTERS ACCEPT  
WORKPIECES CLAMPED TO PALLETS AND CHANGE  
PALLETS AUTOMATICALLY IN SECONDS.  
FIXTURING IS BUILT ON THE PALLETS RATHER  
THAN ON THE MACHINE TABLE. WORKPIECES  
ARE UNLOADED AND LOADED ON THE PALLET  
OUTSIDE THE MACHINING ZONE.

SCENE 59.

**WH59A, SME4304, 04:44:03:00-04:44:17:00**  
pallet of finished parts taken from mill  
**WH59B, SME4304, 04:41:15:00-04:41:50:00**  
wide, finished pallet pulled from mill,  
pallets rotated to new workpieces

**NARRATION (VO) :**

FOR VERTICAL MACHINING CENTERS WITH  
PALLET AUTOMATION, SMALL WORKPIECES MAY  
BE SECURED ON PRE-FIXTURED MINI-PALLETS  
FOR PARTS THAT ARE RUN REPEATEDLY.  
KEEPING THE WORKHOLDING IN STORAGE  
MINIMIZES SETUP TIME.

SCENE 60.

**WH60A, SME4304, 04:44:39:00-04:44:54:00**  
pallet of raw work stock placed in mill

**NARRATION (VO) :**

THESE MINI-PALLETS TYPICALLY MATE WITH A

FIXED PALLET RECEIVER OF KNOWN LOCATION ON THE MACHINE TABLE. THIS ENSURES PROPER PART LOCATION WITHIN THE MACHINE TOOL'S WORKSPACE.

--- TOUCH BLACK ---

SCENE 61.

**WH61A, SME4395, 05:05:04:00-05:05:53:00**  
wide, finished parts pulled from pneumatic fixtures, new parts placed and pneumatically actuated, doors closed for machining

**NARRATION (VO) :**

SOME WORKHOLDING ALTERNATIVES ALLOW CLAMPING FOR HIGHER-VOLUME PRODUCTION. FOR EXAMPLE, HYDRAULIC OR PNEUMATIC CLAMPING IS COMMON IN APPLICATIONS WHERE THE SPEED GAINED IS WORTH THE WORKHOLDING INVESTMENT. HYDRAULICALLY- OR PNEUMATICALLY-ACTUATED CLAMPS CAN PERFORM THOUSANDS OF CLAMPING CYCLES, AND MANY CAN BE COMBINED AROUND A SINGLE WORKPIECE. WHEN THE OPERATOR PUSHES A BUTTON, MULTIPLE CLAMPS MOVE SIMULTANEOUSLY TO GRASP AND HOLD PARTS ON A FIXTURE.

SCENE 62.

**WH62A, SME4379, 10:49:16:00-10:49:50:00**  
zoom out, machining of flat plastic parts using vacuum workholding

**NARRATION (VO) :**

ANOTHER PUSH-BUTTON CLAMPING METHOD IS A VACUUM WORKHOLDING SYSTEM. THESE SYSTEMS SECURE TYPICALLY FLAT WORKPIECES QUICKLY BY THE APPLICATION OF NEGATIVE PRESSURE, FIXING THEM IN PLACE FOR MACHINING.

SCENE 63.

**WH63A, SME4374, 04:50:56:00-04:52:12:00**  
wide, dedicated fixturing of parts, edit at multiple points

**NARRATION (VO) :**

AT THE EXTREME END OF WORKHOLDING ARE



APPLICATION-DEDICATED FIXTURES.  
DEDICATED FIXTURES ARE PRIMARILY USED  
FOR THE MASS PRODUCTION OF SPECIFIC  
PARTS, ALLOWING HIGHLY ACCURATE PART  
LOCATION, FOOLPROOF PART LOADING, AND  
SIMPLE AUTOMATION. DEDICATED FIXTURES  
OFFER LITTLE FLEXIBILITY, BUT THEY DO  
OFFER SPEED, RELIABILITY, AND ACCURACY  
OVER A PRODUCT'S LIFETIME.

--- FADE TO BLACK ---

SCENE 64.

**WH64A**, CGS: Lathe Workholding  
white text, centered on background  
**FMP BKG**, motion background

SCENE 65.

**WH65A**, **SME4125**, **16:18:14:00-16:18:25:00**  
zoom in, large turning operation

**NARRATION (VO) :**

IN TURNING, THE WORKPIECE ROTATES  
INSTEAD OF THE CUTTING TOOL, SO THE  
WORKHOLDING REQUIREMENTS DIFFER.

SCENE 66.

**WH66A**, **SME4369**, **21:25:57:00-21:27:08:00**  
c.u. workpiece in chuck, starting to  
rotate, multiple cutting tools used, edit  
at multiple point

**NARRATION (VO) :**

THE WORKHOLDING DEVICES MUST TRANSMIT  
TORQUE TO ROTATE THE WORKPIECE AND  
WITHSTAND THE CENTRIFUGAL FORCE  
DEVELOPED BY THAT ROTATION.

SCENE 67.

**WH67A**, **SME4316**, **10:05:40:00-10:05:53:00**  
chuck holding workpiece  
**WH67B**, **SME2518**, **01:21:55:00-01:21:59:00**  
collet placed in spindle  
**WH67C**, **SME2645**, **04:04:11:00-04:04:14:00**  
mandrel holding part  
**WH67D**, **SME4362**, **14:01:02:00-14:01:18:00**  
between centers turning with lathe dog  
**WH67E**, **SME2650**, **01:01:10:00-01:01:15:00**  
turning with face driver

**NARRATION (VO) :**

LATHE WORKHOLDING DEVICES INCLUDE THE  
CHUCK...,  
THE COLLET...,  
THE MANDREL...,

AND A MEANS OF ROTATING THE WORK FOR  
BETWEEN-CENTER TURNING, SUCH AS A DRIVE  
DOG...,  
OR FACE DRIVER.

SCENE 68.

**WH68A, SME2537, 01:03:47:00-01:04:13:00**

3-jaw chuck using tailstock for support on  
large workpiece

**NARRATION (VO) :**

A SUPPORT, SUCH AS A TAILSTOCK CENTER,  
CAN ALSO BE ADDED TO THE END OF THE  
WORKPIECE OPPOSITE THE CHUCK OR OTHER  
WORKHOLDING DEVICE. THIS ALLOWS THE  
LENGTH OF WORK EXTENDING FROM THE  
WORKHOLDING DEVICE TO BE INCREASED  
SEVERAL TIMES.

--- TOUCH BLACK ---

SCENE 69.

**WH69A, SME4317, 11:45:08:00-11:45:22:00**

zoom out, 3-jaw chuck used in turning  
operation

**WH69B, SME2642, 01:25:10:00-01:25:30:00**

alternate shot, part placed in 3-jaw  
chuck, rotated

**WH69C, SME2644, 03:03:48:00-03:03:56:00**

6-jaw chuck holding part, removed

**NARRATION (VO) :**

THE SELF-CENTERING 3-JAW CHUCK, EITHER  
MANUAL OR POWER-OPERATED, IS THE MOST  
COMMON AND ECONOMICAL FORM OF LATHE  
WORKHOLDING. SELF-CENTERING CHUCKS MAY  
ALSO USE SIX JAWS.

SCENE 70.

**WH70A, SME2642, 01:02:59:00-01:03:08:00**

part placed in 3-jaw chuck

**WH70B, SME2642, 01:03:15:00-01:03:23:00**

part spun in chuck

**NARRATION (VO) :**

IN 3- AND 6-JAW CHUCKS, A STOP SETS THE  
LENGTH OF THE WORK, WHILE THE JAWS  
ESTABLISH THE CONCENTRICITY OF THE  
WORKPIECE WITH THE LATHE'S SPINDLE.

SCENE 71.

**WH71A, SME2650, 01:19:42:00-01:19:55:00**

master jaws on chuck, moving

**NARRATION (VO) :**

THE THREE MOVING "MASTER JAWS" HAVE  
SERRATED TEETH AND ARE MOUNTED 120

DEGREES APART WITHIN THE CHUCK BODY.

THEY MOVE SIMULTANEOUSLY.

SCENE 72.

**WH72A, SME2650, 01:22:36:00-01:23:00:00**

top jaws placed on master jaws

**WH72B, SME2650, 01:23:03:00-01:23:17:00**

zoom out all top jaws in place, jaw  
tightened

**NARRATION (VO) :**

THE TEETH OF THE MASTER JAWS ENGAGE WITH  
THE TEETH ON THE BOTTOM OF  
INTERCHANGEABLE "TOP JAWS", WHICH CLAMP  
THE WORKPIECE OR BAR STOCK FOR TURNING.  
STANDARD TOP JAWS ARE MADE IN SETS OF  
THREE, AND ARE OF A VARIETY OF DESIGNS  
FOR DIFFERENT APPLICATIONS.

SCENE 73.

**WH73A, SME2642, 01:06:32:00-01:06:44:00**

jaws clamping outside diameters

**WH73B, SME2642, 01:18:14:00-01:18:22:00**

jaws clamping inside diameters

**NARRATION (VO) :**

"TOP JAWS" CLAMP INWARD, TO GRAB OUTSIDE  
DIAMETERS...,  
AND OUTWARD, TO GRAB INSIDE DIAMETERS.

SCENE 74.

**WH74A, SME4379, 10:04:07:00-10:05:26:00**

soft jaws attached to chuck, part secured,  
part turned, edit at multiple points

**NARRATION (VO) :**

WHERE ACCURATE CONCENTRICITY WITH A  
PREVIOUSLY MACHINED DIAMETER IS  
REQUIRED, SOFT TOP JAWS MAY BE MADE.  
THESE ARE BORED TO SIZE AFTER THEY ARE  
MOUNTED IN POSITION ON THE MASTER JAWS.

SCENE 75.

**WH75A, SME4386, 18:15:28:00-18:15:34:00**

automatic chuck accepting part, freeze  
last frame if necessary

**WH75B, SME4386, 18:16:44:00-18:16:48:00**

c.u. footswitch

**WH75C, SME2643, 02:22:55:00-02:23:02:00**

alternate shot, automatic chuck accepting  
part, freeze last frame if necessary

**WH75D, SME2643, 02:24:42:00-02:24:50:00**

alternate shot, zoom in, automatic chuck  
accepting part

**WH75E, SME2643, 02:25:06:00-02:25:11:00**

alternate shot, c.u. footswitch

**NARRATION (VO) :**

THREE-JAW CHUCKS DESIGNED FOR CNC LATHES  
ARE AUTOMATIC, ACTIVATED BY A FOOTSWITCH  
OR OTHER SWITCH TO OPEN AND CLOSE.

SCENE 76.

**WH76A, SME2643, 02:17:33:00-02:17:40:00**  
chuck/collet pads with part, freeze last  
frame if necessary

**NARRATION (VO) :**

HYDRAULIC TYPE CHUCKS REQUIRE A DRAW  
TUBE OR, IN SMALLER CHUCKS, A DRAWBAR,  
TO ACTIVATE THE CHUCK.

SCENE 77.

**WH77A, SME2644, 03:07:46:00-03:08:00:00**  
4-jaw chuck turning non round part,  
stopping  
**WH77B, SME2644, 03:14:16:00-03:14:30:00**  
4-jaw chuck jaws being adjusted  
independently

**NARRATION (VO) :**

THE 4-JAW CHUCK IS USED FOR NON-  
SYMMETRICAL OR NON-ROUND WORK THAT MUST  
ROTATE ON A CENTERLINE. HERE, WORK  
CENTERING TAKES TIME, AS EACH JAW IS  
ADJUSTED INDEPENDENTLY.

SCENE 78.

**WH78A, SME2644, 03:14:45:00-03:14:53:00**  
2-jaw chuck holding non round part

**NARRATION (VO) :**

SOME NON-ROUND WORKPIECES FIT BETTER IN  
A TWO-JAW CHUCK, IN WHICH THE JAWS ARE  
SPECIALLY MACHINED TO GRIP THAT PIECE.

SCENE 79.

**WH79A, SME2644, 03:09:34:00-03:09:48:00**  
4 jaw chuck turning

**NARRATION (VO) :**

SETUPS IN BOTH FOUR-JAW AND TWO-JAW  
CHUCKS MUST BE TESTED FOR BALANCE BEFORE  
BEING ROTATED AT TURNING SPEEDS.

SCENE 80.

**WH80A, SME2649, 00:00:52:00-00:01:01:00**  
index chuck, indexing part  
**WH80B, SME2649, 00:01:41:00-00:01:56:00**  
index chuck, turning, indexing part

**NARRATION (VO) :**

WORKPIECES THAT HAVE INTERSECTING AXES,  
SUCH AS VALVE BODIES, MAY BE MACHINED ON  
TWO, THREE, OR FOUR SURFACES IN AN  
INDEXING CHUCK. THESE CHUCKS INDEX THE  
WORKPIECE, PRESENTING SEVERAL SIDES TO  
THE CUTTING TOOL. JAWS FOR INDEXING  
CHUCKS MUST BE CUSTOM-MADE FOR THE

WORKPIECE.

--- TOUCH BLACK ---

SCENE 81.

**WH81A, SME2520, 03:06:58:00-03:07:24:00**  
collet being placed into spindle, work  
placed in collet, collet tightening, edit  
at multiple places  
**WH81B, SME4361, 13:50:30:00-13:50:45:00**  
zoom out, collets

**NARRATION (VO) :**

COLLETS CLAMP ACCURATELY ON SMOOTH  
SURFACES WITHOUT MARKING OR DISTORTING  
THE PART. COLLETS COME IN A WIDE RANGE  
OF SIZES AND TYPES AND ARE TYPICALLY  
USED TO SUPPORT ROUND BARS OR  
CYLINDRICAL SLUGS.

SCENE 82.

**WH82A, SME2645, 04:06:11:00-04:06:17:00**  
square collet, part placed in it  
**WH82B, SME2648, 21:19:32:00-21:19:40:00**  
multisize collet  
**WH82C, SME2643, 02:02:35:00-02:02:43:00**  
part turning in multisize collet

**NARRATION (VO) :**

STANDARD COLLETS ARE ALSO AVAILABLE IN  
SQUARE AND HEX SHAPES. SOME COLLETS ARE  
MULTISIZED, WITH A STEPLESS GRIPPING  
SIZE RANGE OF ABOUT ONE EIGHTH OF AN  
INCH, OR 3 MILLIMETERS. MULTISIZE  
COLLETS ACCOMMODATE FRACTIONAL, DECIMAL,  
METRIC, AND NON-STANDARD BAR SIZES.

SCENE 83.

**WH83A, SME3453, 21:22:53:00-21:23:09:00**  
c.u., collet used in plastic bar feed  
operation  
**WH83B, SME4353, 05:12:55:00-05:13:09:00**  
zoom out, multiple bar stock feeders

**NARRATION (VO) :**

COLLETS ARE THE PREFERRED METHOD OF  
WORKHOLDING FOR BAR STOCK APPLICATIONS  
THAT INCLUDE AUTOMATIC BAR FEEDING AND  
BAR CHUCKING.

SCENE 84.

**WH84A, SME2639, 02:02:56:00-02:03:04:00**  
zoom in, empty collet chuck

**NARRATION (VO) :**

POWERED COLLET CHUCKS USE AN INTERNAL  
COLLET INSTEAD OF JAWS. COLLET CHUCKS  
CLAMP WITH A GREATER FORCE THAN COLLETS  
ALONE.

SCENE 85.

**WH85A, SME2520, 05:05:35:00-05:05:48:00**  
long shaft being turned  
**WH85B, SME2519, 02:07:56:00-02:08:00:00**  
center holes on ends of stock, loop if  
necessary  
**WH85C, SME2518, 01:24:00:00-01:24:10:00**  
tailstock with conical pin  
**WH85D, SME2519, 02:08:04:00-02:08:13:00**  
move tailstock, place work between centers

**NARRATION (VO) :**

LONG WORKPIECES MAY REQUIRE BETWEEN-CENTER TURNING. HERE, A TAILSTOCK CENTER SUPPORTS THE END OF THE WORK OPPOSITE THE CHUCK OR COLLET. THE TAILSTOCK ASSEMBLY MAY BE MOVED MANUALLY OR BY PROGRAMMED COMMAND TO SUPPORT DIFFERENT LENGTH WORKPIECES.

SCENE 86.

**WH86A, SME2644, 03:23:25:00-03:23:44:00**  
zoom out, steady rest assisting between centers turning

**NARRATION (VO) :**

SINCE CUTTING FORCES MUST BE LIMITED IN BETWEEN-CENTER TURNING, IT IS EFFECTIVE TO SOMETIMES ADD A STEADY REST TO SUPPORT LONG WORK.

SCENE 87.

**WH87A, SME2644, 03:22:15:00-03:22:27:00**  
steady rest replacing tailstock for workpiece end operation

**NARRATION (VO) :**

ALSO, A STEADY REST MUST BE USED RATHER THAN A TAILSTOCK WHEN WORKING ON THE END OF A LONG PART.

SCENE 88.

**WH88A, SME2650, 01:01:08:00-01:01:22:00**  
c.u. face driver, freeze last frame  
**WH88B, SME2650, 01:01:42:00-01:01:53:00**  
c.u. face driver, part secured to it

**NARRATION (VO) :**

FOR TURNING SHAFTS, ONE TECHNIQUE IS TO USE A FACE DRIVER--A TOOL WITH A CENTER POINT AND SEVERAL DRIVING PINS LOCATED IN A CIRCLE, WHICH DIG INTO THE END OF THE SHAFT.

SCENE 89.

**WH89A, SME2650, 01:03:28:00-01:03:52:00**  
med, face driver turning

**NARRATION (VO) :**

THE FACE DRIVER PROVIDES THE TORQUE, WHILE A LIVE CENTER, HELD IN THE TAILSTOCK, PROVIDES SUPPORT.

SCENE 90.

**WH90A, SME2644, 03:18:40:00-03:18:46:00**  
drive dog turning shaft

**WH90B, SME2650, 01:04:47:00-01:05:03:00**  
face driver turning, finishing shaft

**NARRATION (VO) :**

UNLIKE CHUCKS OR DRIVE DOGS, THE FACE DRIVER ALLOWS CUTTING TOOL ACCESS TO THE FULL LENGTH OF A SHAFT. THE DIRECTION OF CUTTING IS GENERALLY TOWARD THE FACE DRIVER, TO MAINTAIN THE DRIVING PRESSURE ON THE PINS.

SCENE 91.

**WH91A, SME2644, 03:25:59:00-03:26:15:00**  
mandrel expanding to hold part, turning

**NARRATION (VO) :**

EXPANDING MANDRELS, ALSO CALLED ARBORS OR EXPANSION COLLETS, GRIP ROTATIONAL PARTS FROM THE INSIDE DIAMETER.

SCENE 92.

**WH92A, SME2645, 04:04:10:29-04:04:11:00**  
freeze frame, thin part held by mandrel

**WH92B, SME2645, 04:05:00:00-04:05:12:00**  
thin part in mandrel, being turned

**NARRATION (VO) :**

A MANDREL WORKS WELL FOR THIN-WALLED WORKPIECES AND ALLOWS ACCESS TO THE FULL EXTERIOR OF THE WORKPIECE.

SCENE 93.

**WH93A, SME2645, 04:03:08:00-04:03:27:00**  
freeze first frame, slit sleeve & internal arbor

**WH93B, SME2644, 03:28:22:00-03:28:31:00**  
mandrel with different diameter sleeve, expanding & contracting

**NARRATION (VO) :**

MANDRELS ARE MADE UP OF TWO HIGHLY CONCENTRIC CYLINDERS: AN EXTERNAL DOUBLE-SLIT SLEEVE AND AN INTERNAL ARBOR. ONE ARBOR WILL SUPPORT A RANGE OF DIAMETERS OF EXPANDING SLEEVES. EXPANDING MANDRELS OR SLEEVES ARE MANUAL OR POWER OPERATED.

SCENE 94.

**WH94A, SME2648, 21:17:30:00-21:17:45:00**  
magnetic chuck holding, turning workpiece

**WH94B, SME4358, 10:46:20:00-10:46:34:00**  
zoom in, milling using magnetic plate

**NARRATION (VO) :**

A MAGNETIC CHUCK CAN BE USED TO GRIP IRREGULARLY-SHAPED, FERROUS WORKPIECES AS LONG AS THEY HAVE ONE FLAT SURFACE.

MAGNETIC PLATES, CUBES, OR TOMBSTONES  
ARE ALSO USED WITH MILLING.

--- FADE TO BLACK ---

SCENE 95.

**FMP RVW**, CGS: Review  
white text, centered on background  
**FMP BKG**, motion background

**MUSIC UP AND UNDER**

**NARRATION (VO) :**

LET'S REVIEW THE MATERIAL CONTAINED IN  
THIS PROGRAM.

SCENE 96.

**WH07A, SME4303, 03:12:12:00-03:12:22:00**  
zoom out, part being held, machined  
**WH14A, SME2638, 01:18:12:00-01:18:22:00**  
part released from workholding, freeze  
last frame  
**WH14B, SME2638, 01:18:23:00-01:18:35:00**  
new part secured onto workholding  
**WH15A, SME4132, 03:22:12:00-03:22:43:00**  
clamped part being machined

**NARRATION (VO) :**

WORKHOLDING STARTS FROM TWO PRINCIPLES:  
FIRST, A WORKPIECE MUST BE HELD IN A  
SETUP THAT GUARANTEES A DEFINITE  
LOCATION, OR POSITION AND ORIENTATION IN  
SPACE, PART-AFTER-PART. SECONDLY, THE  
WORKHOLDING DEVICE MUST HOLD THE PART  
SECURELY IN POSITION WHILE CUTTING  
FORCES, VIBRATIONS, CENTRIFUGAL FORCE,  
AND GRAVITY ACT TO DISLODGE IT.

SCENE 97.

**WH10D, SME4025, 10:18:00:00-10:18:20:00**  
unloading, loading workpiece, edit at  
multiple points  
**WH11A, SME2638, 01:16:02:00-01:16:09:00**  
workholding being setup  
**WH11B, SME2638, 01:14:36:00-01:14:43:00**  
workholding being torn down  
**WH10E, SME4091, 07:24:36:00-07:24:43:00**  
milling of transmission housing

**NARRATION (VO) :**

TO MEET PRODUCTIVITY DEMANDS,  
WORKHOLDING DEVICES MUST BE EASY TO  
LOAD...,  
AND UNLOAD...,  
SETUP...,  
AND TEARDOWN.  
WORKHOLDING DEVICES MUST ALSO ALLOW  
CUTTING TOOLS ADEQUATE ACCESS TO THE  
WORK.



SCENE 98.

**WH17A, SME4315, 09:30:27:00-09:30:53:00**  
zoom out, machining part  
**WH18H, six degrees of freedom**  
**WH18H, counterclockwise rotation of axes**  
appears

**NARRATION (VO) :**

WHEN PROPERLY CLAMPED, WORKHOLDING  
DEVICES SHOULD PREVENT WORKPIECE  
ROTATION AND MOVEMENT IN ANY PLANE,  
RESTRAINING IT IN ALL SIX DEGREES OF  
FREEDOM.

SCENE 99.

**WH28A, SME4094, 09:13:00:00-09:14:10:00**  
parts being machined using various cutting  
tools, edit at various points

**NARRATION (VO) :**

FOR PART ACCURACY AND PRODUCTIVITY, THE  
WORKHOLDING SHOULD ALSO ALLOW AS MANY  
MACHINING OPERATIONS AS POSSIBLE IN A  
SINGLE CLAMPING.

SCENE 100.

**WH36A, SME4367, 19:44:38:00-19:45:00:00**  
zoom out, clamps holding mold half during  
milling  
**WH41C, SME2645, 04:09:53:00-04:10:02:00**  
odd shaped part secured in vise

**NARRATION (VO) :**

BASIC CLAMPS...,  
AND VISES ARE EFFECTIVE FOR LOW-VOLUME  
WORKHOLDING FOR MILLING.

SCENE 101.

**WH58A, SME4356, 09:31:31:00-09:31:52:00**  
swapping tombstones  
**WH58C, SME4306, 06:31:39:00-06:31:51:00**  
part set up on tombstone

**NARRATION (VO) :**

MACHINING CENTERS MAY USE PALLETS FOR  
WORKCHANGING, AND MUCH WORKHOLDING IS  
BUILT UP ON A PALLET BASE RATHER THAN  
THE MACHINE TABLE.

SCENE 102.

**WH59B, SME4304, 04:41:15:00-04:41:41:00**  
wide, finished pallet pulled from mill,  
pallets rotated to new workpieces  
**WH41D, SME4394, 04:49:07:00-04:49:33:00**  
multiple three jaw vises with parts  
removed

**NARRATION (VO) :**

TRADITIONAL CLAMPS AND VISES USED IN  
MILLING ARE SUPPLEMENTED ON MACHINING  
CENTERS BY MINI-PALLETS...,  
AND MULTI-VISES.

SCENE 103.

**WH49B, SME4018, 02:20:25:00-02:20:45:00**  
zoom out, cutter/work moving

**NARRATION (VO) :**

**WH49A, SME4386, 18:48:41:00-18:48:59:00**  
part machined, rotary table indexing to  
new position

ROTARY TABLES...,  
AND INDEXERS PROVIDE ACCESS TO  
ADDITIONAL WORKPIECE SURFACES IN  
MACHINING CENTERS.

SCENE 104.

**WH63A, SME4374, 04:50:56:00-04:52:12:00**  
wide, dedicated fixturing of parts, edit  
at multiple points

**WH57A, SME4315, 09:14:59:00-09:15:09:00**  
pan fixture with part

**NARRATION (VO) :**

FIXTURING CAN RANGE FROM DEDICATED  
FIXTURES CONSTRUCTED FOR SPECIFIC  
WORKPIECES IN HIGH-VOLUME PRODUCTION, TO  
FIXTURES BUILT UP FROM MODULAR ELEMENTS  
IN LOW-QUANTITY PRODUCTION.

SCENE 105.

**WH61A, SME4395, 05:05:04:00-05:05:53:00**  
wide, finished parts pulled from pneumatic  
fixtures, new parts placed and  
pneumatically actuated, doors closed for  
machining

**NARRATION (VO) :**

HYDRAULIC AND PNEUMATIC CLAMPING IS  
RELIABLE, POWERFUL, AND CAN REDUCE  
WORKHANDLING OR SETUP TIMES.

SCENE 106.

**WH65A, SME4125, 16:18:14:00-16:18:25:00**  
zoom in, large turning operation

**NARRATION (VO) :**

IN TURNING, WORKHOLDING MUST BOTH ROTATE  
THE WORKPIECE AND RESIST CENTRIFUGAL  
FORCES.

SCENE 107.

**WH69B, SME2642, 01:25:10:00-01:25:30:00**  
part placed in 3-jaw chuck, rotated

**WH73A, SME2642, 01:06:32:00-01:06:44:00**  
jaws clamping outside diameters

**WH73B, SME2642, 01:18:14:00-01:18:22:00**  
jaws clamping inside diameters

**NARRATION (VO) :**

THE 3-JAW CHUCK IS THE MOST COMMON  
WORKHOLDING DEVICE FOR LATHES. IT IS  
LIMITED TO HOLDING CYLINDRICAL WORK. IT  
MAY CLAMP INWARD ON OUTSIDE  
DIAMETERS...,  
OR CLAMP OUTWARD ON INSIDE DIAMETERS.

SCENE 108.

**WH82A, SME2645, 04:06:11:00-04:06:17:00**  
square collet, part placed in it

**WH84B, SME2643, 02:08:23:00-02:08:32:00**

**NARRATION (VO) :**

COLLETS...,

collet chuck turning workpiece  
**WH83B, SME4353, 05:12:55:00-05:13:09:00**  
zoom out, multiple bar stock feeders

AND COLLET CHUCKS HOLD SMOOTH-SURFACED,  
SMALL-DIAMETER WORK PRECISELY AND DO NOT  
MAR THE WORK SURFACE. BOTH WORK WELL  
WITH BAR FEEDERS.

SCENE 109.

**WH69A, SME4317, 11:45:08:00-11:45:22:00**  
zoom out, 3-jaw chuck used in turning  
operation

**WH87A, SME2644, 03:22:15:00-03:22:27:00**  
steady rest replacing tailstock for  
workpiece end operation

**WH88B, SME2650, 01:01:42:00-01:01:53:00**  
c.u. face driver, part secured to it

**NARRATION (VO) :**

BETWEEN CENTER TURNING USES SUCH DEVICES  
AS THE TAILSTOCK...,  
THE STEADYREST...,  
AND THE FACE DRIVER.

SCENE 110.

**WH91A, SME2644, 03:25:59:00-03:26:15:00**  
mandrel expanding to hold part, turning

**NARRATION (VO) :**

EXPANDING MANDRELS WORK WELL ON THIN-  
WALLED PARTS WITH THROUGH HOLES. THEY  
ALLOW ACCESS TO THE ENTIRE EXTERIOR OF  
THE WORKPIECE.

--- FADE TO BLACK ---

SCENE 111.

continue music, up and under  
**WH CRX**, CGS, ROLL: credits  
white text, fade up mid-screen  
**FMP EXM**, extended motion background

Produced By:  
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SCENE 112.  
continue motion background  
**FMP DIS**, CGS: disclaimer  
white text, centered on background

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 113.  
**FMP SME**, SME logo open, with music

