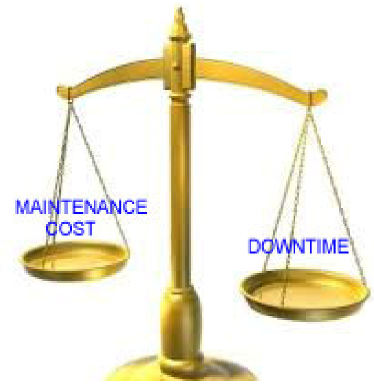
Managing Extrusion Maintenance

We recognize <u>Light Metal Age Magazine</u> for their founding support for this Manual

Maintenance managers must balance **low maintenance cost** and **minimum "downtime"** – the maximum reliability of the production equipment. Maintenance may be cut back for the short term, but eventually there is a price to pay. Ignoring or delaying necessary maintenance will eventually cost more in downtime and deferred costs. *"Pay me now or pay me later."*



In this chapter we explore some ideas and tools to help manage maintenance more efficiently:

Following is from a paper prepared for ET22, also presented at IMEDAL:

Improving Maintenance Efficiency

By Al Kennedy

Abstract

In the 1980’s DuPont commissioned the largest ever benchmarking study of maintenance and reliability practices. It included a study of 3500 sites across North America, Europe and Japan. It was so extensive that we still refer to it today[1].

The study concluded that the top 5% of these companies, the so-called **“Best of the Best”** do the basics very well. And those basics include Planning and Scheduling.

That DuPont study and the many studies since then have repeatedly shown that maintenance productivity is often poor, and typically as low as 20% to 30%. That means that during a typical 10-hour day your average technician only spends 2 to 3 hours doing actual maintenance work, sometimes even less. So, when you pay your maintenance technicians for a full day’s work you actually only get about 2 to 3 hours of your money’s worth. And no, that’s not because your technician isn’t working hard, it’s because you make it too hard for your people to do the right thing. The average day is simply filled with too much inefficiency and waste.

But it doesn’t have to be like that. We know from those same studies that with an effective maintenance planning and scheduling process you can grow your productivity to 45%. And as you continue to improve you can increase your productivity to world class levels of 55% or 60%.

In this paper some methods are presented for increasing maintenance efficiency.

The Typical “Old” Methods

From my own experience as mechanic’s helper, many years ago, this is how a typical job was done:

1. Go to the job site, see what parts and tools are needed
2. Return to the work shop for tools and parts
3. Often the necessary tools or parts are not available – search and try to find, can’t find
4. Report to foreman, get assigned a new job
5. Repeat steps 1 to 4

[1] Hupje, Erik, “Without Maintenance Planning and Scheduling You Will Fail,” November 2017, www.roadtoreliability.com

Benefits of Changing the Way Maintenance is Managed

How efficient is maintenance work? A benchmark study in the 1980s by Dupont was conducted to measure maintenance efficiency. They studied 3500 sites in the Americas, Europe, and Japan.

The study measured “wrench” time, the actual time spent doing repair work. From the benchmark study, typical maintenance productivity was found to be very low, 20% to 30%.

So you pay for a full day’s work, but actually get only 2 to 3 hours of maintenance work.

It is not that the technician isn’t working hard, it is too hard to do the right thing. There is too much inefficiency and waste in the “system.”

With **Planning and Scheduling**, efficiency may be increased to 45%. And with continued improvement, world-class levels of 55% to 60% are possible. An efficiency increase to 45% is like a 35% increase in the work force!

Planning & Scheduling eliminates waste of the following types:

- Delays and lost time during the completion of jobs
- Incorrect identification of materials resulting in false starts, delays or makeshift repairs
- Poor co-ordination of personnel resulting in excessive waiting and idle time
- Bad timing of equipment isolation and shutdown resulting in excessive downtime.

With Planning & Scheduling you may accomplish:

- Improved quality of work, supporting increased reliability
- Increased uptime and integrity of critical equipment
- Improved safety by performing work in a prepared way
- More job satisfaction and a greater sense of ownership among your teams.

Build a **reliability culture**

The improvements in job satisfaction and ownership usually come from:

- Better use of people’s time, with less waste and less frustration. Nobody likes to see their time wasted.
- Making the CMMS[2] work for you and your people, rather than the other way around. Nothing is as frustrating as being a slave to a system.
- Reducing fire-fighting and chasing “someone else’s emergencies”

Planning refers to **preparing a job** so you can do that job without unnecessary delays. This requires identifying and preparing:

- the scope of work
- the procedures you’d need to do that work safely and properly
- the materials you’d need
- any external (specialist) services
- any specials tools etc.

Scheduling, on the other hand, **focuses on what work gets done when and by whom**.

- Scheduling also looks at how you group work to minimize waste: Waste such as equipment down time, travel time to the job, etc.
- Scheduling also balances the workload against available resources.

[2] CMMS: Computerized Maintenance Management System

Planning maintenance is about the **"WHAT"** and **"HOW"** of a maintenance job. Scheduling refers to the **"WHO"** and **"WHEN"**. *To succeed in improving your productivity* ***you need both Planning and Scheduling****. Planning alone or scheduling alone just won't cut it.*

Efficient maintenance requires a focus on Breakdown vs. Planned Maintenance.

Breakdown (also called *Reactive*) maintenance is inefficient:

- Only one problem is fixed
- Skilled people are not always available
- Spare parts and test equipment are not always available
- Production workers are idle during repairs

Planned maintenance is more efficient:

- Many problems are worked on at the same time
- Skilled people will be planned to be available
- Spare parts and test equipment will be planned to be available
- Production workers are scheduled off

The goal: make 90% of work Planned *not* Breakdown. How is this change made? There are several ways to reduce unplanned breakdowns:

- Regular scheduled work days
- Inspections and tests to predict needed repairs
- Modify and revise equipment to prevent failures

The Planning Process

The process begins by defining the planning team, which includes the maintenance supervisor, plant operations, and a designated planner. The planner is a distinct job position and requires a good knowledge of maintenance work, as well as ability to work well with the technicians and supervisors.

The planning team communicates daily to review and approve all work requests. They will identify and prioritize the work for the next day, and specify any special considerations.

Planning Steps: the planner then plans for the following requirements for each job:

- What information is needed? (Drawings or manuals)
- What spare parts & materials will be needed, and are they available to the job site.
- What special tools or equipment will be required?
- Are there any safety considerations?
- Coordinate the shut-down requirements with operations.
- Determine if there are special lifting or rigging requirements, and make arrangements if needed.

Note that each technician will have his own idea how to do the job. Many will not like being told how to do the work, BUT **Variability is the enemy of quality!** The planner must work to gain cooperation by the technicians and agreement on standard procedures.

The Scheduling Process

The first job of scheduling is to prepare a weekly schedule, that is approved by the supervisor or manager and coordinated with operations. "Emergency" changes to the schedule must be approved by the supervisor or manager.

Supervisors must continually "feed back" progress on the schedule and the hours available for work. This will help update the schedule and assist with scheduling for remaining work.

Completion and Follow-up

When each job is completed it is important to follow up and evaluate the work:

- Accuracy of planning – were the estimated manpower, time, etc., correct?
- Problems encountered – spare parts, equipment, information?
- Operations – downtime required, coordination with operations, success of repairs.

This post-job follow-up will help to improve the process for future planning and scheduling.

Who will do Planning & Scheduling?

The planning and scheduling jobs must be separate job from the supervisors of the workers, who should not have time for this work in addition to supervising the actual work. The number of staff (one, two, or more) will depend on the size of the department and available staff.

The planner/scheduler must have strong knowledge of mechanical/electrical work, and must communicate well with the technicians and supervisors. Inter-personal skills are important.

This job is also good preparation for higher management positions.

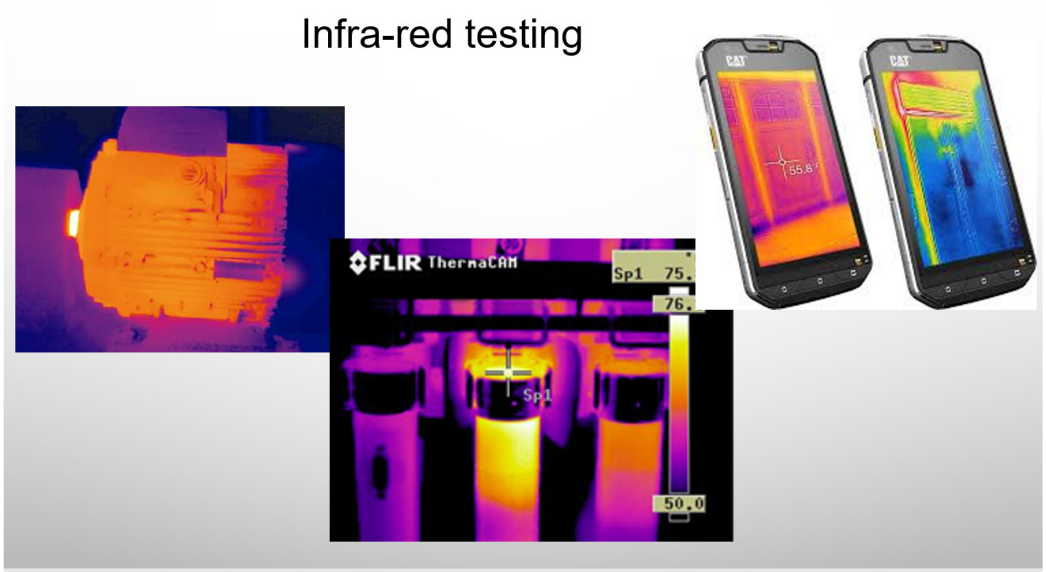
A final task of the Scheduler is to develop a 12-24 months look ahead. This flags major maintenance well in advance, which is critical to managing long lead items. It also helps to group to maximize efficiency and reduce downtime.

For extrusion plants, following are examples and tests to reduce unplanned breakdowns:

Maintenance Schedules: Regular schedules for work are necessary. Typical schedules for extrusion equipment are available at www.pressmanual.online Chapter A. These schedules for extrusion plants may be downloaded at www.alkennedy.net/pressmanual in Microsoft® Excel format, and customized to your needs.

Hydraulic Oil Testing: Testing of hydraulic oil is necessary for good hydraulic reliability. Sampling procedures and examples of test results are available at www.pressmanual.online Chapter 5 – Hydraulics.

Infra-red Inspection: Scans of equipment with infra-red scanners will detect problems before failure occurs. Information on scanners is available at www.pressmanual.online Chapter 6. Scanners are now available for smartphones; see www.flir.com



Testing Press Components: Structural components of presses should be examined routinely to detect signs of fatigue failure. References and procedures are available at www.pressmanual.online Chapter 4.

Spare Parts Inventory

Maintaining the necessary supply of spare parts is a primary responsibility of supervisors and also planners. If needed parts are not on hand when needed, make it known and take steps to have them ready the next time. See Chapter B www.pressmanual.online for important points on extrusion plant recommended spare parts and their storage.

Spare parts for an extrusion plant usually represent a major investment, typically about 5% of initial equipment cost. Still, most plants experience some downtime waiting for parts, and spend considerable time and effort having parts specially made or flown in on a rush basis. Maintenance workers usually complain that the stockroom doesn't have what they need, but instead is filled with items they don't use, and even many obsolete or useless items. Go through the parts inventory a couple of times every year to clean out obsolete items and note anything important that may be missing. A carefully thought-out spare parts policy may well save you from disaster some day. It is best if prepared in written form. It should include:

- a plan for every major component – whether to stock it, wait until needed to buy it, or to have it made (the decision is based on delivery and how critical the parts are)
- a system for keeping an inventory of components such as containers and stems, which are repaired and returned to inventory (in some plants, used parts are not included in the inventory records system)
- regular screening for and removal of obsolete parts
- proper storage conditions and occasional inspection of spares
- Some press components such as hydraulic cylinders, pumps, and electric motors have special storage requirements. *See Chapter B – Spare Parts.*

Equipment Information Files and History

You must obtain *and save* equipment information – drawings, part numbers, manuals, diagrams --- and make it available to workers. In my experience people remove documents from the files and they are not available when needed. Sometimes complete information is not received on new equipment. When new equipment is purchased, complete data must be required as part of the purchase contract. Get it in electronic format so that it can be easily saved and copied for anyone who needs it. Maintenance work is much easier when necessary information is available.

When new equipment is purchased, make it part of the Purchase Order to obtain good original vendor information, with enough copies to provide a back-up. For this reason we recommend using a **Vendor Information Requirements** sheet, such as in Figure E-1. This form will be included with the **Purchase Order and contract** for equipment any time new equipment is purchased, and made a part of the Purchase Order. Note that the form lets you specify as electronic media --- drawings in CAD format and manuals as word processor files. These formats protect against loss and allow you to make fresh copies as needed.

Once the information is received, it should be distributed (usually copies to Production, Maintenance, and Engineering) and also properly archived to insure against loss over the years. By “archives” we mean a separate, locked, fire-proof file in a separate location. Personal Computer technology makes it easy to create archives on magnetic media, but a “hard copy” archive is still recommended, with access permitted only to make copies, never to remove the original document from the archives. (We have seen too many plants that have lost all the drawings and other documents of key equipment, and these plants often pay dearly for the lack of information, or they must pay to obtain replacement documents.)

What can be done in an older plant after the original information has been lost? First set up a proper information file system and an archive, starting by listing each piece of equipment and creating a file folder for each. Next go out to the equipment and record any nameplate data, and then contact the original manufacturer to request copies of any information still available. In some cases it is be necessary to make new drawings by measuring directly from the equipment.

It is important for maintenance personnel to have complete access to the data in the equipment information files, as well as to the repair history. For this reason a notebook or tablet computer seems ideal, although some documents such as large drawings or manuals are more difficult to scan into memory and to recall. For these items conventional file cabinets are still needed, along with secure back-up archives to guard against loss of the documents. Files should be properly indexed to simplify locating the correct data.

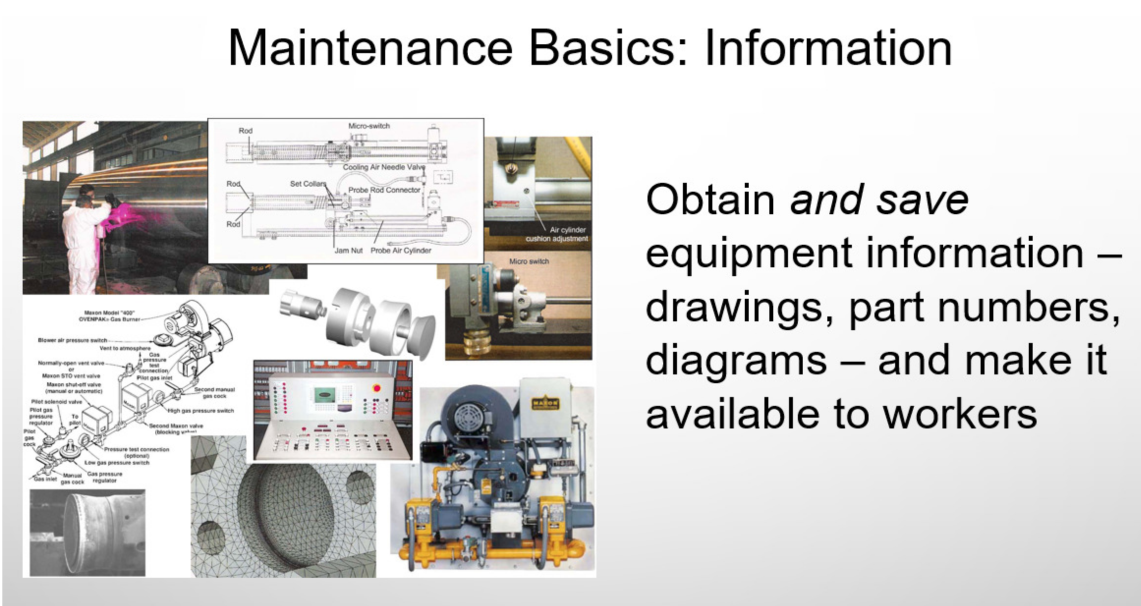


Figure E-1:

Equipment Data Requirements Sheet

Date____________________ **Project**__________________ **PO No.**__________

Supplier______________________ **Equip. Description**____________________

This sheet specifies the technical data required from the vendor of the subject equipment purchase. This sheet is part of the purchase agreement, and the order will not be complete until all requested data has been received.

Equipment Data Required:

Type:	Hard Copies:	Media Copies (specify):
Instruction Manuals:		
Performance Curves or Tables (Pumps and Blowers)		
Parts Assembly Diagrams		
Complete Parts List		
Recommended Spare Parts		
Maintenance Instructions		
Lubrication Requirements		
Engineering Drawings:		
Layout Drawings		
Detail Parts Drawings		
Foundation Requirements		
Electrical & Controls:		
Schematic Diagrams		
Program Print-out		

Notes: ____

____

Send Data to: ____

____

____

Maintenance Engineering

Most plants, regardless of age or design, will profit from an activity which we call Maintenance Engineering --- **reducing maintenance costs and downtime by finding engineering solutions for recurring problems.** The problems to be solved are identified from records of cost, downtime, and repair histories, and from the recommendations of production and maintenance workers. A regular Pareto analysis of downtime --- summarizing downtime for each component of the press line --- is the best way to identify priority items for maintenance engineering.

To some extent, all maintenance and production workers should be involved in Maintenance Engineering, and encouraged to identify problems and offer solutions wherever possible. However, in larger, older plants, it is usually justified to assign one or more full-time engineers to the activity, due to the technical skills needed and the number of opportunities for cost reduction. In any case, Maintenance Engineering should be a formal program, with regular management reports that list the problems, priorities, potential savings, and the name of the person responsible for each item.

Many solutions to maintenance problems will be found in new materials and technologies in the marketplace, so the Purchasing department should also be involved in contacting vendors and finding sources of new technology.

Maintenance Staffing and Required Skills

Perhaps the major responsibility of maintenance management is providing the correct staffing to meet the needs of the plant – the right number of people with the proper skills at the right time.

In extrusion plants we generally find an average staffing level in the range of **200 to 400 maintenance man-hours per press per month**. This figure includes direct hours worked on the press line alone (not including equipment in the foundry, finishing, or packing areas), and it varies according to many factors, for example:

- age of the equipment
- size of the press
- design and complexity of the equipment
- skill level of maintenance workers
- whether preventive or breakdown maintenance is followed
- use of press operators and/or outside contractors for some work

Some months there will be peaks where somewhat more man-hours are required, but on average the indicated range should be expected.

Most extrusion plants have a continuing problem in finding and keeping maintenance workers with the necessary skills. Working conditions are often brutal – hot, dirty, and stressful.

The best solution is to focus on improving working conditions: not only pay and benefits, but also the work environment and the way the work is performed. Try scheduling maintenance shut-downs during mid-week, when parts suppliers are open and vendors are available for technical support. Your workers will thank you. By moving away from **reactive** to **proactive** maintenance, you will improve working conditions and save money for the company at the same time.

A good source for maintenance workers that is often overlooked is the press crew. Consider the advantages of moving press operators into maintenance: they already know the equipment, they are comfortable with the plant environment, and their loyalty to the company has been demonstrated. They only need to be trained in the necessary skills.

There are several resources for obtaining training for extrusion plant maintenance workers:

- the Aluminum Extruders Council offers Press Maintenance Seminars to its members every 2 or 3 years
- vendors such as Bosch Rexroth and Allen Bradley offer specialized training on their equipment
- maintenance seminars or in-house training are occasionally offered by consultants

These resources will complement the courses available at local technical schools.

Performance Measurement

For the sake of measuring performance, it is useful to track the following data on a monthly basis or more often, for each press (in multi-press plants):

- maintenance man-hours
- percent overtime for maintenance workers
- hours + minutes of press downtime for planned maintenance
- hours + minutes of press downtime for breakdowns (unplanned maintenance)
- maintenance costs

One goal is to minimize the downtime for breakdowns, in favor of planned maintenance. Another goal is to hold maintenance overtime to less than 20% over any extended period --- more than 20% overtime over an extended period is uneconomical and inefficient, as workers' productivity will likely suffer due to fatigue.

The Maintenance Level Audit

A useful tool for finding the correct balance between maintenance cost and downtime is the Maintenance Level Audit. The purpose is to measure the condition of the plant, with respect to maintenance, on an imaginary rating scale from 0 to 5.

- A level of 5 represents a perfectly maintained plant: everything perfectly clean and painted, no oil leaks, no vibrating machines, etc.
- A level of zero represents the opposite extreme: a complete mess, guards missing, fluids leaking, machines neglected, broken down and falling apart.

The scale from 0 to 5 then represents proportional stages between these extremes.

To measure the maintenance level, a **team of 2 to 5 inspectors** goes to each department or extrusion press and rates it as well as possible based on visible evidence; rating each element such as pumps, piping, machine guards, paint, fluid leaks, vibrations and noise, etc. Even though it is only possible to evaluate visible conditions by this method, the results are in fact a remarkably good picture of the entire maintenance level, including downtime and repair costs.

Now, with the concept in mind that **maintenance level can be measured**, it becomes easier to discuss the philosophy of the maintenance program. To illustrate, imagine a plant with a maintenance level of 1.0. There we might see such things as visible oil leaks, rags, and dirt, which will eventually result in a contaminated hydraulic system, dirty filters, pump and valve failures, and press downtime. What could have been repaired early for a few dollars now costs thousands, including major breakdown time. **A maintenance level at the low end of the scale indicates a short-sighted and costly maintenance program.**

At the other extreme, it is also possible to over-maintain a plant, for example by excessive painting, cleaning and polishing. Once a certain level is reached, additional inspecting, polishing and cleaning will add little to reliability. Now, this writer has visited some 165 extrusion plants and has never seen a 5 (and very few 4's). Even so, it would seem wasteful to maintain the plant at level above 4. One would never maintain an extrusion press to the level of a boiler room or perhaps a fire truck, where there are workers available with extra time to clean and polish the equipment.

So the ideal level of maintenance seems to be in the range from 2.5 to 3.5, with small problems being spotted and corrected early before they become big, costly problems; and wherever possible to err on the side of doing more than the minimum, not less. This seems to be the level that corresponds to maximum uptime while minimizing the cost over the long term.

When trying to reduce maintenance costs, always keep in mind that cutting costs is not really saving money if the maintenance level is reduced in the process. A good maintenance level is like money in the bank, and allowing maintenance level to decline is like using up the money that was invested for the future. Of course in times of extreme production demands or financial crisis, it may be necessary to somewhat neglect maintenance for a short time. The level might be allowed to decline to, say, 2.0; but it should never be allowed to get too low or else recovery will be very difficult and expensive. And allowing a decline in the maintenance level must never be considered anything but temporary; after all, it is not a cost saving, but a postponement of costs, a borrowing from the future; and the plant must eventually be returned to the economical range 2.5 to 3.5.

The Maintenance Level Audit is conducted by a team of 2 to 5 persons, who come from different backgrounds and departments, and from different plants if possible. Use a checklist similar to Figure E-2 (develop your own if possible). Each team member grades each item and the results are averaged. Collecting this data on a quarterly or semi-annual basis will provide a useful ongoing measure of maintenance performance.

Figure E-2:

Maintenance Level Audit (Sample Form)

Date_________________________ Audited By____________________________________

Location____

Note: Grade each item on a scale of O (Worst) to 5 (Best)

Item🡻 Department🡺	**Press 1**	**Press 2**	**Press 3**
Housekeeping			
Floors, walkways, & ladders			
Mechanical Equipment:			
Functions smoothly			
Vibration			
Lubrication			
Hydraulic Systems:			
Oil leaks			
Shock or hammer			
Temperature control			
Electrical Equipment:			
Control cabinets			
Conduit & wiring			
Lighting			
Safety Equipment:			
Guards			
Protective equipment			
Piping Systems:			
Hydraulic			
Compressed air			
Water			
Other			
Heating Equipment			

Following is an update to a paper that was presented in March, 2003, at the Aluminium 2000 Conference in Rome:

High-Tech Tools for Extrusion Plant Maintenance

by Al Kennedy

The methods and tools for maintaining extrusion presses and related equipment have been greatly improved in recent years, and some older tools have found new applications. Examples include: lasers for alignment and leveling; infra-red thermal imaging; digital videos and still photos; hand-held computers; document storage, transmittal, and retrieval, including via the internet; and barcoding. Older technologies have found new applications, for example: ultrasound and MPI analysis of press components; hydraulic fluid analysis; and pressure grouting for foundations.

Many plants, however, don't take advantage of the available technology. In this paper we explore many of these tools and technologies that are available, and how to apply them in the extrusion plant maintenance program to reduce costs and improve reliability.

Hydraulic oil analysis. Valuable information may be obtained from an Oil Analysis service. Most contaminants in hydraulic oil are invisible to the human eye. Damage-causing particles range from 5 to 40 micrometers in size, but the limit of human visibility is only 40 micrometers. Also, acids, water, and other by-products of oxidation cannot be easily detected by human senses. Therefore, oil sampling and analysis by other means is necessary.

On-site tests are possible by means of a Patch Test Kit, which gives immediate information. However, the range of detail provided is very limited, and the Patch Test Kit should only be used for a quick look at short term problems.

Complete laboratory analysis is the preferred method of oil testing. Numerous test labs, especially suppliers of oil and hydraulic equipment, offer these services. Oil samples are gathered, labeled, and sent in, at a frequency ranging from monthly to semi-annually. The test report should be returned within 24 to 48 hours after receipt, and will indicate such information as:

- Spectrochemical analysis of wear metals and additives.
- Particle count over various size ranges, also expressed as an ISO cleanliness code.
- Viscosity at 100°F.
- Water content expressed as a percent of volume.
- Analysis recommendations.

This data will indicate any corrective action or modifications that should be made to the hydraulic system.

For more details on hydraulic oil sampling see Chapter 5 – Hydraulics.

Ultrasound and Magnetic Particle testing. For many extruders, these types of tests are well known. They permit non-destructive testing of major press components, such as tie rods and main cylinders, for cracks that indicate the beginning of fatigue failure. By finding cracks early, and tracking their progression over a period of months or years, it is usually possible to minimize the risk of lost production by obtaining a replacement component well in advance of failure. The new part may then be installed at the most convenient time, and in a planned, organized way, to minimize cost and downtime.

Fatigue failure is a common problem for extrusion presses, due to the many millions of cycles of operation over a few years of life. For presses in which no cracks have yet been detected, an annual test with either Ultrasound or MPI is recommended. After cracks have been detected, follow-up inspections are recommended at a frequency that depends on the size and rate of progression of the crack or cracks.

Inspection services are usually obtained from specialized contractors, although a few large extruders employ their own specialist to test presses on a regular schedule.

Ultrasonic inspection uses sound waves of short wavelength and high frequency to detect flaws **(Figure E-3)**. Pulsed beams of high frequency ultrasound are used via a hand-held transducer which is placed on the specimen. Any sound from that pulse that returns to the transducer (like an echo) is shown on a screen which gives the amplitude of the pulse and the time taken to return to the transducer. Defects anywhere through the specimen's thickness reflect the sound back to the transducer. Flaw size, distance and reflectivity can be interpreted.

Magnetic Particle Testing (MPT) is accomplished by inducing a magnetic field in a ferromagnetic material and then dusting the surface with iron particles (either dry or suspended in liquid). Surface and near-surface imperfections distort the magnetic field and concentrate iron particles near imperfections, previewing a visual indication of the flaw. **(Figure E-4)**.

Because of its complexity, considerable technician training and skill are required to use either of these testing methods.

Additional illustrations and discussions of Ultrasound and Magnetic Particle Testing may be found in **Chapter 4 – Major Components**.

Figure E-3: Ultrasound testing

Magnetic particle shows cracks in a hot container housing

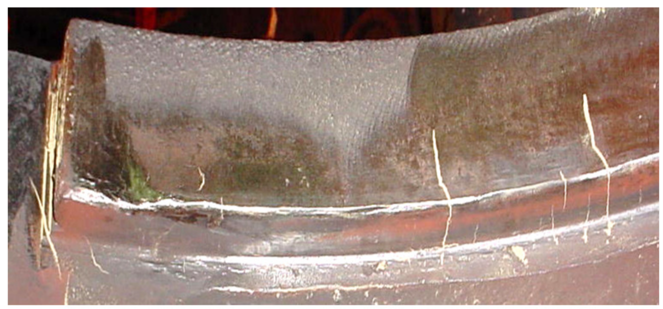


Figure E-4: Magnetic Particle testing

Infrared thermal imaging. Much of our plant equipment will tell us its condition if we will only check its temperature. That job is made easier with Infrared Thermal Imaging systems, camera-like devices that show an image of the equipment, color-coded according to its actual temperature. Originally applied primarily to electrical switchgear, the technology has now been applied to a wide spectrum of applications, such as hydraulic components --- anywhere in the plant that differential temperature may indicate trouble or malfunction.

One useful application is to inspect the thermal insulation of billet heaters, die heaters, and age ovens. Infra-red imaging will identify whether insulation has failed or settled, and whether door seals are working properly.

Typically, the first inspection in an older plant will find, at a minimum, several instances of over heated electrical devices and poorly conductive connections. Often, these are in need of immediate correction for safety reasons **(Figures E-5 and E-6)**.

Infrared imaging are now available as attachments to smart phones. Large plants should consider purchasing a thermal imaging device. Smaller plants may obtain the service from a contractor, until such time that they feel that it is justified to purchase their own equipment instead.

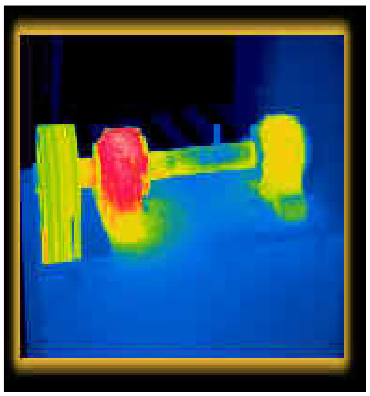


Figure E-5: Infrared image of an overheated bearing

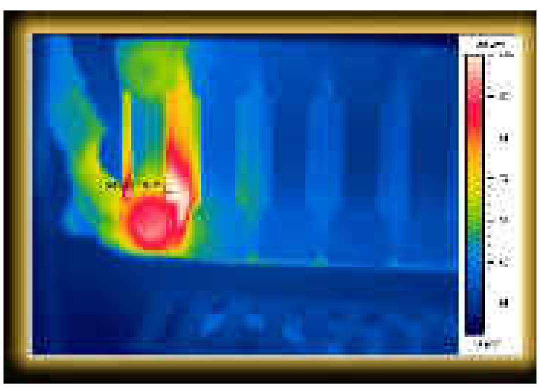


Figure E-6: Infrared image of an overheated fuse block

For other examples see Chapter 6 – Electrical & Controls.

Digital imaging. Today almost everyone carries a smart phone with a camera capable of still and video photography, and the possible uses are many:

- Die makers and die users exchange information about dies and their performance with digital photos sent by email or other methods.
- Records of breakdowns and inspections can be backed up with images that are easily stored on computer media and retrieved as needed. "A picture is worth a thousand words."
- Communication with equipment suppliers, consultants, and others, about breakdowns or replacement parts, is infinitely more effective if accompanied by digital photos.
- Analysis of dynamic problems such as the movements of the press, can be made more quickly and accurately by means of video (preferably digital) that can be viewed in slow motion or stop-action, and also viewed repeatedly. The press cycle can be recorded once and then viewed "off line" while the press returns to normal production.
- Most phones may be fitted with a small, inexpensive microscope that fits over the camera lens. With this item it is possible to examine and photograph details such as metallurgical failures -- is it fatigue or tensile failure?
- A USB microscope attached to a personal computer or laptop costs a tiny fraction of the cost for a lab-grade microscope, yet allows metallurgical details to be observed.
- A USB "bore scope" uses fiber optics to allow viewing inside equipment or other formerly inaccessible places.

Electronic document storage, retrieval, and transmission. One of the most annoying problems maintenance technicians face is the lack of good information about the equipment they maintain. In most older plants, copies of data sheets, drawings, and instructions have been lost through the years. We recommend taking the time to reconstruct lost data files, and to create a special fireproof archive storage room or cabinet to keep them safe. When new equipment is purchased it is critical to obtain good documents, in a suitable electronic format, and to properly archive it. Fortunately, today's information technology offers the tools to make the "information gap" a thing of the past. Some of the specific tools and procedures recommended are:

- Use a standardized form to specify the data required when new equipment is purchased. See the sample in **Figure E-1**. Note that documents are requested in electronic format as well as hard copies – word processor or CAD versions.
- Create a secure archive, either in a fireproof room or stored off-site, for storing the original copies of all documents. These are accessed only to replace working copies when needed --- never to be taken onto the plant floor.
- Copy all important existing documents to an electronic filing format, for example as *.pdf files (portable document format). A good scanner with document feeder, which will likely come packaged with filing software, is the first step. The files are then archived on CD's or other back-up devices.
- Once data files are converted to electronic format, in-plant access by intranet (wireless?) becomes practical for the technician at the press. Documents may also be transmitted to vendors or engineers for trouble-shooting or technical support.

An investment in equipment data files may seem uninteresting and low priority compared to other daily problems. However, good information is absolutely essential to efficient maintenance, and once the information has been lost, it will be very expensive or even impossible to completely replace it.

Internet Sources. Most questions about equipment and maintenance may be answered using search engines such as **Google**.

Example: a recent search was made for information about "roller chain," a component often used in puller drives. A simple search yielded the following:

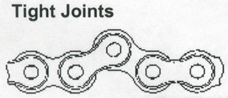
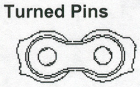
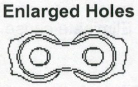
- Roller Chain Drives Troubleshooting Guide at www.maintenanceresources.com. This printable guide (Figure E-7) is helpful in diagnosing failures. It is free of charge and available in an instant, along with similar guides on Roller Chain Installation, Lubrication, and Maintenance; not to mention other topics such as bearings, belt drives, oil analysis, gears, hydraulics, vibration, etc., from the same source.
- Specifications and international standards for this product and related components.
- Numerous sources for this product from around the world, allowing a quick search for the lowest-cost source and fastest delivery, no longer limited to the local suppliers.

These results are typical; previous searches have been used to find lower cost sources for: electric motors; other power transmission components; computers and printers and related supplies; tools and diagnostic equipment; etc. Management ought to ensure that plant maintenance people have this tool at their disposal.

Figure E-7:

Roller Chain Drives

Troubleshooting Guide

CONDITION/SYMPTOM	POSSIBLE CAUSE	WHAT TO DO
Tight Joints 	• **Dirt or foreign material in chain joints.**	Clean and relubricate chain.
	• **Inadequate lubrication.**	Replace chain. Re-establish proper lubrication.
	• **Misalignment.**	Replace sprockets and chain if needed. Realign sprockets.
	• **Internal corrosion or rust.**	Replace chain. Eliminate cause of corrosion or protect chain.
	• **Overload bends pins or spreads roller.**	Replace chain. Eliminate cause of overload.
Rusted Chain	• **Exposed to moisture.**	Replace chain. Protect from moisture.
	• **Water in lubricant.**	Change lubricant. Protect lubrication system from water. Replace chain.
	• **Inadequate lubrication.**	Provide or re-establish proper lubrication. Replace chain, if needed.
Turned Pins 	• **Inadequate lubrication.**	Replace chain. Re-establish proper lubrication.
Enlarged Holes 	• **Overload.**	Replace chain. Eliminate cause of overload.

Pressure Grouting. It is not unusual, especially in older press plants, to find that foundations have tilted or settled. We have even seen some plants with foundations that allow the press to move up and down significantly with every cycle. Clearly this condition would make it impossible to maintain the proper press alignment and may cause constant shifting in the relative positions of the main cylinder and die platen, depending on the rigidity of the press support frame.

Conventional foundation repair requires a great expense and loss of production while the press is removed, the old foundation is excavated, and a new foundation poured and cured. Fortunately, technology has given us a new alternative.

Pressure grouting is defined as "an injection under pressure of fluid material into fractures and cavities in rock, soils or artificial structures." Foundation problems such as vibration, leakage, water cut-off, deficient bearing and others that may be encountered in new construction or existing structures can often be solved by pressure grouting using cement or chemical grout. Many structures and floors have been raised back to original elevation by a controlled grouting program.

Figure E-8: Illustration of Pressure Grouting

Pressure grouting offers many useful methods. One common solution involves drilling a small hole (or holes) for access to the area beneath the foundation **(Figures E-8 and E-9)**. Special grouts are then pumped through the holes under high pressure. Pressures are high enough to even lift the press and foundation to their original position if necessary. The chemical grouts are typically quick-setting, with a variety of desirable properties available to suit particular needs. The entire operation may be conducted in a matter of hours, with minimal interruption and reasonable cost.

Specialized firms offering this service are available throughout the world. An Internet search on Pressure Grouting yields thousands of references, for example:

www.technicalfoundations.com.

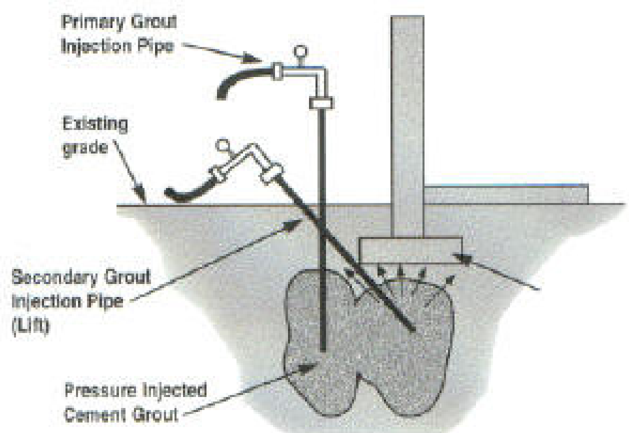


Figure E-9: Diagram of Pressure Grouting

Lasers for leveling and alignment. New laser based devices and systems are now available for a variety of extrusion plant maintenance applications, primarily for leveling and alignment.

It is recommended that the extrusion run-out bed, puller tracks, and cooling system be checked for proper level and alignment each year. The press frame should also be checked for level, to ensure that settling of the foundation has not occurred. The purpose of these checks if to maintain smooth mechanical function and provide for smooth, drag-free transfer of profiles throughout the plant. Today, the preferred tool for these tasks is the laser surveyor's level **(Figure E-10)**, which can be quickly and easily set up and operated with a minimum of skilled manpower.

Figure E-10: Rotary laser level

A new technique for aligning press components was presented by Joseph Mulder at ET 2000 Conference[3] and substantially updated at ET16[2]. According to Mulder:

"Previously published methods of extrusion press alignment made use of traditional mechanics' tools such as precision levels, piano wire, micrometers, and various jigs and fixtures. Alignments were not made with the press under load, nor at operating temperature.

"More modern methods of measurement are desirable in order to improve accuracy and to take readings under actual operating conditions. Advances with surveying instruments began by using triangulation (intersection) with digital theodolites systems.

"In this paper, the latest methods using 3D Laser Tracking technology are presented. Additional benefits of this system have been identified, including: improved profile tolerances; significant production improvements; dummy block wear significantly reduced and total failures eliminated; longer container liner service life; noticeably less wear to ram and container guide-way bronze wear strips; and stem replacements minimized. Some observations are made regarding press establishment, press benchmarking, and the combined tolerances and error propagation effects for press frame alignment."

Mulder's paper goes on to describe the complete, 3-dimensional realignment of an aluminum extrusion press with laser surveying instruments.

[3] Mulder, Joseph E. V., and Smith, Gavin J., "Extrusion Press Alignment with Modern Technology," Proceedings of 7th International Aluminum Extrusion Technology Seminar, (2000).

[2] Mulder, Joseph E.V., "Laser Tracker Measurement Technology for the Alignment, Correction, Condition Monitoring, and Refurbishment of Extrusion Presses," *Proceedings of 11th International Aluminum Extrusion Technology Seminar,* (2016), p.555-565.

Barcode tracking for tools and spare parts. Many plant computer systems only keep track of new spare parts; they do not account, for example, for spare **press containers and dummy blocks**, which are routinely repaired and returned to storage. It is left to the memory of someone in the plant whether the spare container is ready for use when needed; and the same is true for other major press parts. We have previously recommended that the computerized parts tracking system include these parts as well. Now there is an excellent tool for keeping such records with a minimum of cost and without relying on personal memory.

Barcode tracking systems **(Figure E-11)** have been greatly improved and may be easily applied for a small investment. Coding software, printers, and scanners are commonly available for ordinary PC's. For larger parts, portable scanners may be used with smart phones or tablet PC's. The system is also useful for keeping a record of company owned tools such as drills, special wrenches, hydraulic jacks, etc.

One consideration to keep in mind when developing such a system: the next generation of technology, already under development, will replace the barcodes with inexpensive microchips that can be read from a distance with electronic scanners. This technology is already undergoing testing for supermarket checkouts in the US.

A similar tool is use of QR Codes, which contain lots of information and are easily created and scanned ad with free software. For example:

Figure E-11: Barcode identification and tracking of tools