Human Factors in Record Retention

INTRODUCTION

The purpose of this paper is to examine how human factors concerns impact records retention practices in a midsize aerospace manufacturing firm. The paper briefly covers the concerns under a manual, paper based records retention system and then moves on to examine the issues and concerns associated with implementing an electronic records management system.

An aerospace manufacturing company operates in a very competitive business environment. Customers demand high quality products, produced at the lowest possible cost and delivered on schedule to the right location every time. Regulatory agencies such as the Federal Aviation Administration (FAA) in the United States and the Joint Aviation Authorities (JAA) in Europe require manufacturers to provide proof that their products meet specified standards for safety and quality.

Records provide the foundation of this proof and they are extensive. Aerospace companies keep detailed records of everything from the request for quote up to and including individual part production records. In addition, the regulatory agencies require traceability. Engineering designs are developed, tested and documented to provide the evidence required to obtain regulatory agency approval of the type design. The part manufacturer must be able to identify the materials used in production, down to the specific lot, batch or serial number. There must be evidence proving that these materials met all of the approved engineering requirements.

The traceability concept requires that material suppliers provide material certifications, test reports and first article inspection reports along with their shipments. The receiving group captures this documentation and files it for later use. It provides the evidence that only approved and tested materials went into the production of the aircraft components.

The manufacturer also documents the entire component build process. Engineering checks and approves all drawings prior to production release. Manufacturing engineers interpret the drawings and develop the manufacturing plans and bill-of-materials used by shop personnel to build the parts. A manufacturing tracer and a copy of the manufacturing plan provide the shop personnel with the authorization to build the part. The manufacturing tracer also becomes the complete record of the manufacturing steps, materials and labor used to manufacture the part, thus ensuring part integrity and traceability.

The information contained in all of these records is useful only when it is readily available. Paper based records management systems are no longer capable of adequately supporting the modern aerospace manufacturing company. The problem is to identify and implement a cost effective records management solution that meets these requirements (Barrett, 2005).

Paper Records

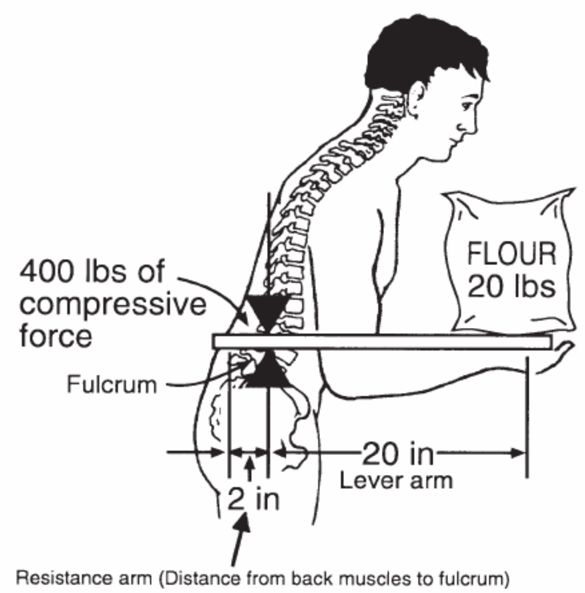
As previously noted, the current manufacturing system generates a large volume of records. The company is rapidly expanding. New contracts have production rates at 16,000 to 18,000 parts per month. Each part represents at least one and often multiple records being generated. The record volume will only grow as additional new work is won.

Currently, there are 12 pallets or roughly 600 boxes of these tracers being stored on shelving in the factory. They represent slightly less than three years production and are part of the legacy left following conversion to electronic records management. Each of these boxes is heavy and awkward to handle. Each box weighs roughly 40 lbs and was handled multiple times before reaching its storage location. The legacy records will be converted to electronic storage as time permits.

The process placed empty boxes in the shipping area. Shipping personnel separated the records from the part at the time of shipment. The records were accumulated by date and placed in the boxes. Filled boxes were moved to a “hot storage” location in the records managers’ office. After roughly 90 days, the records were taken back out to the shipping area where they are placed on a pallet for longer term storage. Once palletize, the boxes of records were covered with plastic and banded to the pallet. They were then lifted onto a storage rack with a forklift.

Manual handling of bulk records is limited but still represents a risk and possible hazard to the employees charged with moving them. (Note: Management is having the legacy records converted by area workers as time permits.) The Washington State Department of Labor data shows that 60% of their overexertion claims are the result of strains and sprains of the body trunk. Improper lifting techniques or a twisting motion with the lift can result in serious injury to the spine (DOL, 2000).

Figure 1



Another concern is the disc compressive forces experienced by the worker when lifting the full boxes. Body position can have a major impact on these forces. The lower back functions as a fulcrum point for the upper body and any weight lifted by the arms. The further the weight is from the body, the higher the disc compressive forces are on the lower back region. Figure 1 is from the Washington Department of Labor pamphlet *Lessons for lifting and moving materials.* http://lni.wa.gov/IPUB/417-129-000.pdf#search='disc%20compressive%20forces It illustrates how the lower back region is subjected to 400 lbs of compressive force on the disc at the fulcrum point from a load of just 20 pounds held with the elbows bent at 90 degrees. This compressive force is the result of a combination of the object weight and the upper body as it bends forward. The forward leaning posture can place a large strain on the back muscles as they strive to support the weight of the upper trunk. Adding the additional weight of the records only compounds the problem.

It is entirely possible to injure oneself by simply leaning forward while picking up a piece of paper, let alone a box. With paper records some of these issues can be mitigated through the use of proper lifting techniques and carts to move the records. Ron Miller in his article on Spine-health.com gives three simple rules for proper lifting.

- "Keep the chest forward" – this forces you to keep your back straight instead of bending. It also reinforces bending at the knees in order to lift an object off of the floor.
- "Lead with the hips, not the shoulders" – This reduces the chance of injuries from twisting while lifting. The hips should lead the body through a change in direction so that the shoulders follow.
- "Keep the weight close to the body.' – This reduces the effort needed to support the object while also reducing the stress placed on the lower back (Miller, 2003). http://www.spine-health.com/topics/cd/back_injury/back_injury01.html

Other concerns when dealing with paper records include the tedious and labor intensive manual filing process. This tedium leads to filing errors and lost records. One additional concern is the physical hazard associated with moving palletized records in and out of storage.

Anytime records are moved in palletized lots, there is a risk of injury to the fork lift operator and any workers who happen to be in the area. The greatest risk comes with working with the records overhead such as lifting the pallet to the storage shelf location or removing it from the storage location. Narrow aisle forklifts are notoriously unstable unless loaded and operated with care. A pallet load that is not centered can cause tipping as can sudden changes in direction with the mast raised.

Since a loaded pallet can easily weigh a ton or more, the operator must take care that the safe lifting capacity of the forklift is not exceeded. This can easily happen if the load is picked up by the fork tips or if the mast is tilted forward. Another cause is the use of fork extensions to try and reach loads that are too far back on a shelf. Any of these actions can move the combination of the fork lift and the load center of gravity too far forward, creating a potentially hazardous condition. Page 11 of the Washington State Department of Labor and Industries, Forklift Safety Guide provides additional information on the safe loading of a forklift (DOL, 2001).

The tedium associated with filing can be mitigated somewhat by limiting the amount of time each worker spends filing. This was accomplished with the manufacturing tracers by simply collecting them at the end of the day in clear plastic bags. The bags were simply filed by date collected. No effort was made to sort any of the bag contents, either by lot number or manufacturing location. The boxes were marked with the content accumulation dates and record type.

While this solution reduces the tedium associated with filing the records, it does little to assist the worker who has to retrieve a specific document. Record retrieval is a labor intensive process that requires considerable detective work on the worker looking for the record. Retrieval is normally based on the lot number – part number combination which must be cross-referenced to a hopefully accurate completion date. The employee then uses the completion date to start the search for the actual record, a search that often seems like more of a treasure hunt than a retrieval process. It takes about 10 minutes to retrieve each record, provided it is filed correctly. If there is a disparity between the completion date and when the record shipped, then additional boxes must be moved and searched.

Electronic Record Storage

An increasingly popular solution to the problems associated with the paper records is converting them into electronic records. Ideally, the electronic conversion solution would be total, including the document origination phase. Unfortunately, it is often initially necessary to capture the record in a paper format and then convert it to an electronic media. Once the electronic version is captured and verified, the paper original may be disposed of.

This electronic capture and storage solution brings a whole host of new human factors engineering considerations with it. These considerations include the workstation design, scanner operation as well as data capture and storage software. The hardware and software selected must be easy to use and capable of working with a wide range of employee abilities.

Scanners

The first major consideration is the equipment selection. Scanners range from simple desktop models to highly complex, stand-alone, high-speed scanning stations. The equipment selected must take into account scanning volume, size of source documents, and of course the operator.

High Speed Scanners

Large high-speed systems (over 110 pages per minute) are normally stand alone system that have the user interface built-in, often in the form of a computer monitor. They will also have an input device such as a keyboard and/or mouse. The systems generally are designed so that the operator has to stand while working with the system.

They are typically designed to handle very large record volumes. Some of the problems imposed by this type of system are:

1. The equipment height is typically fixed making it difficult to accommodate the 10% of the workers who are outside the “normal” anthropometric data range of the population.

   In this area, the purchaser is largely relying on the human factors engineering expertise of the manufacturer. The machine height should be set, by the manufacturer, to accommodate the majority of the population.

   For shorter workers, a platform may be needed to help them reach the controls and the document input/removal stations. The platform may be on spring loaded wheels for easy movement. This allows the platform to be quickly moved out of the way when it is not needed. The operators’ weight should compress the spring so the platform rests solidly on the floor when in use.

   Exceptionally tall workers may require a stool that allows them to set during equipment operation. A wheel arrangement similar to the platform may be used to expedite movement into and out of the work zone.

   Another alternative is to have two operators. One who loads and unloads the machine and the other who verifies and stores the scanned images.

2. The monitor and data input locations are built into the equipment and are fixed.

   The operator must move between the monitor and the document input and removal locations. The alternative is to have two operators as noted above. Both operators must be fully trained to operate the machine so that they can switch off at regular intervals of say two hours.

3. This type of system typically requires the operator to stand, often on hard surfaces such as concrete. This can result in back and leg pain.

   A couple of alternatives present themselves. The first is to install anti-fatigue matting running the length of the machine. This high density foam matting provides a protective cushion over the cement floor. The problem with using it is that it may prevent using the moveable platform or at least make the platform difficult to move. The operator may also choose to wear shoes that have built in arch supports and that also cushion the foot.

An alternative is to add a tall stool to allow the operator to vary his or her body position. It would be especially helpful for the verification operator who tends to be “stuck” in a position to view the monitor and use the keyboard.

4. The systems are generally fairly complex to operate.

   All operators will require training before operating the equipment. In addition, system users should also receive training in how to use the software to effectively locate and retrieve the images they need. All training should be documented as part of the employee’s personal record.

Medium and Low Speed Scanners

Medium (45 -110 pages per minute) and low speed (under 45 pages per minute) scanners are normally separate pieces of equipment that are designed to interface with a separate computer system. They allow more flexibility in designing the equipment workstation. Either a stand-up workstation or an adjustable height table is recommended for a medium speed scanner. A stand-up work station should have a downward monitor viewing angle and a keyboard height that allows the users arms to bend at the elbow so the wrists are kept straight when typing. See the workstation design discussion below.

The medium speed systems operate quickly enough that a single operator working at a set-down station would have to do a considerable amount of stretching, reaching and lifting in awkward positions. The alternative would be constantly getting up and down to load the document feeder and remove the scanned documents from the document catcher. A stand-up workstation allows the worker to move about freely to tend the system. By using an adjustable height table, each operator can custom fit the work station to meet his physical requirements. This view point is supported by Kroemer in *Ergonomics, How to Design for Ease and Efficiency,* Chapter 9. Kroemer states “Stand-up work stations should be adjustable to have the input device at approximately elbow height (e.g., between 90 and 120 centimeters) when the operator is standing (Kroemer, 2001, pg 435).” Figure 2 is a picture of an adjustable height table.

The alternative to an adjustable height work station is to custom build one out of a material such as Creform. This solution is only viable if there is a single user of this system or if all users are approximately the same height. It can work, but is much less flexible than the adjustable table. Figure 3 is a picture of a custom made Creform assembly station. A scanning station would be easily constructed using the same materials and techniques.

Low speed scanners such as the HP 5550C are generally too slow for efficient scanning of large quantities of documents. They are best suited for occasional individual scanning operations involving a limited number of documents. As such, they are generally connected to individual PC’s where the requirements of a sit-down workstation are the norm. The sit-down scanning station is essentially the same as the typical computer workstation.

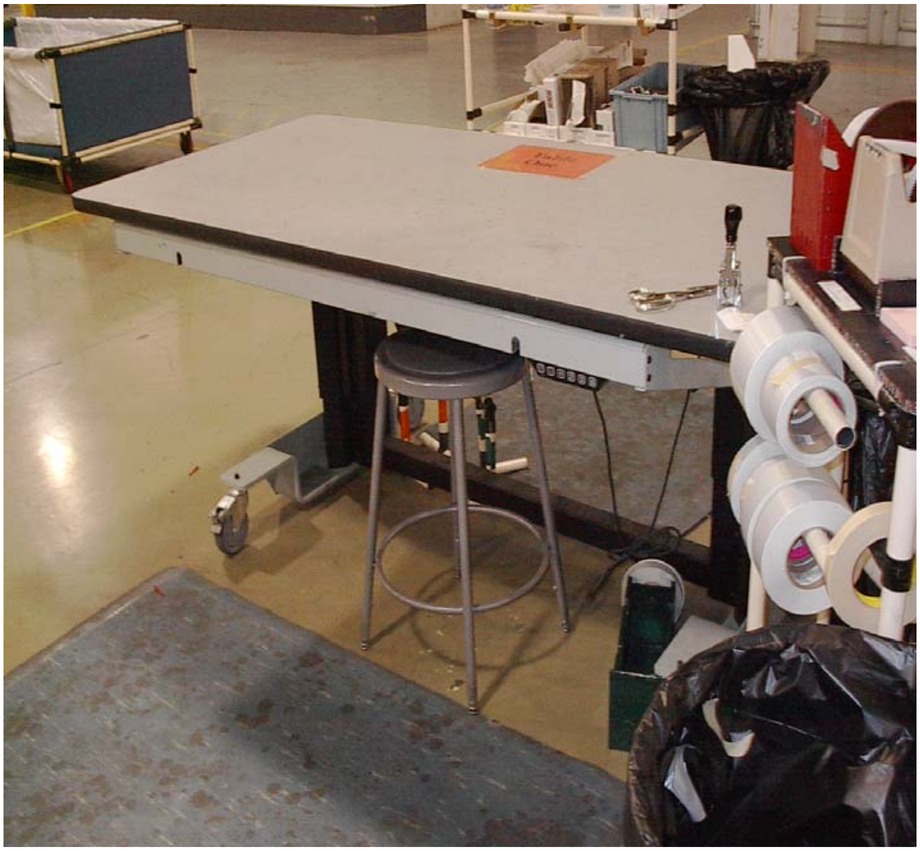


Figure 2

Note the height adjusting buttons below the table on the right side, just to the right of the stool. This table is in the "down" position for seated work. Also note the anti-fatigue mat on the floor in front of the workstation. This particular station is used for assembly operations but is easily configured for scanning operations

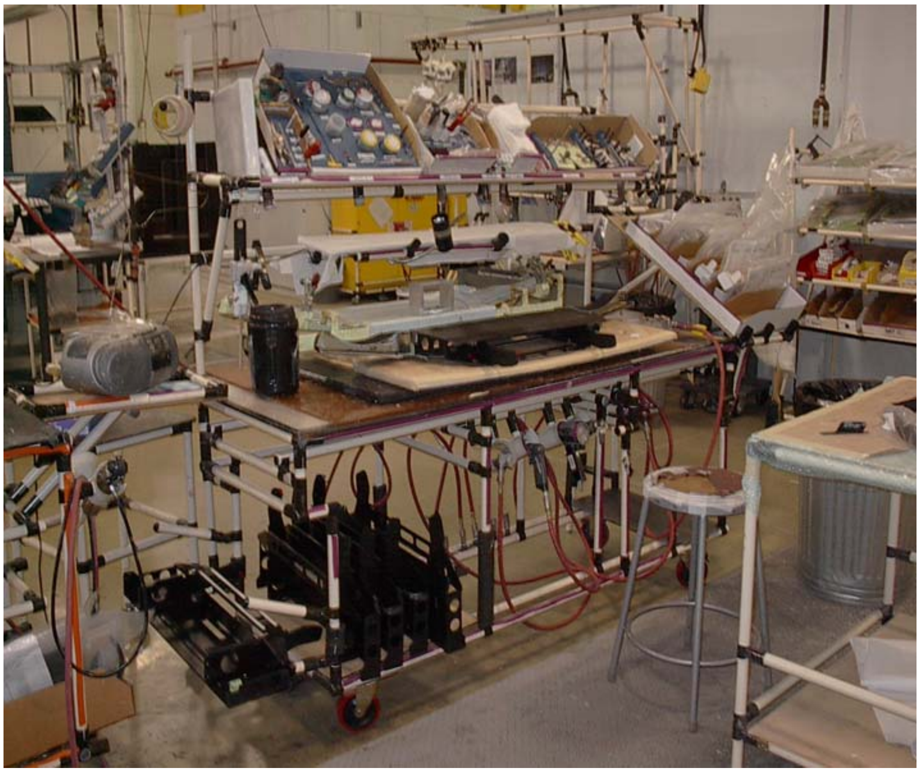


Figure 3

This is a final assembly workstation make from Creform tubing and connectors. The system is easily changed and highly flexible although not height adjustable. This station is designed to have the worker stand or set using a stool during assembly operations. A scanning station without the overhead storage is easily created. The wheels do lock to prevent sudden, unwanted movement. An anti-fatigue mat is used at this station.

The scanning equipment should incorporate several important features to lessen the operator workload and enhance the scan results. These features include:

- An auto feed function so the operator does not have to manually feed the documents one at a time into the scanner.
- Operator selectable duplex capability so both sides of the document are captured when needed without manually feeding the document again.
  Note: that some image capture software has the capability to identify and eliminate blank pages from the data stored. This would allow duplex scanning with mixed documents.
- Color scans so the images provide a true representation of the original document.
- The scanner and software should allow the operator to clear a paper jam without restarting the scan. This is often a problem with low speed, less expensive scanner models.
- The scanner should be compatible with a wide range of document capture packages to allow the system designer to select the best software package for the type of scanning expected.

Workstation Design

In the text *Ergonomics, How to Design for Ease and Efficiency,* Kroemer suggests three strategies for establishing the computer workstation height above the floor. The first is that the work surface, key board height, center of the display and the seat pan are all adjustable. In the second strategy, the support for the keyboard is fixed at 70 cm and all other measurements are adjustable. In the third strategy, the seat pan is fixed at 50 cm and all other measurements are adjustable (Kroemer, 2001, Pg. 431).

Ideally, all workstations would be developed using the first strategy. With everything adjustable, the workstation adapts to fit the user's body measurements. Unfortunately this option is not always achievable. Many of the workstation cubes use a freestanding wall with a work surface attached. While the work surface height is adjustable, it normally requires considerable time and effort to make the adjustment, as well as some tools.

This leads to option two as the norm. The work surface and keyboard height are fixed at around 70 cm or about 27.5 inches. All other components in the workstation are adjustable. The monitor viewing angle should be downward (15 to 45 degrees below the eye-ear plane) when the monitor is placed directly on a work surface set at 70 cm. This allows the workers head to assume a natural, comfortable, neutral position that does not force the neck and shoulder muscles to continually do extra work.

The chair seat pan should be adjusted so that the worker can place the feet on the floor. The knees do not have to be at a perfect right angle to the seat pan. In fact, this is generally not desirable at it will tend to limit leg movements. A footrest may be used, when needed to allow the height to be adjusted to accommodate the correct head position and viewing angle. The user should be aware that a footrest also tends to limit leg movements and is therefore less desirable.

The computer monitor should be sized and placed so that it can display a full page scan that is easily readable by the operator. Monitors that are too small for displayed image, require the operator to scroll through each document, a process that will quickly become tedious and annoying. Placing the monitor on the work surface will provide the proper viewing angle. This angle is typically 15 to 45 degrees below the eye-ear plane. The viewing distance is set in the 18 to 24 inch (45 to 60 cm) range. This allows the worker to assume a natural, relaxed head posture which helps to relieve some of the fatigue, sore shoulders and neck muscles associated with working at a computer (Kroemer, 2001, Ch 9).

The keyboard is best set at 53 to 70 cm above the floor. It should be adjusted so the operator is able to keep the wrists straight in order to reduce the probability of cumulative trauma disorders such as carpel tunnel syndrome. The risk of developing this syndrome increases dramatically when the wrists are hyper-extended either up or down.

The keyboard is best located in front of the monitor. It should be placed so the viewing angle is in the 45 to 75 degree range. This allows the operator to glance downward to see the keys without having to move the head. This viewing angle is necessary due to the complexity of the modern keyboard. With 101+ keys being typical, today's keyboards require the operator to frequently glance down to ensure the fingers are placed correctly, especially when the function keys or numeric pad are used. This downward viewing angle places the keyboard so that bifocals and trifocals work correctly.

One other consideration is if the standard QWERTY keyboard is going to be used. This style of keyboard must be operated with pronated hands, that is with the thumbs down. Since the keys run in straight rows, the hands and fingers must be angled inward (Kroemer, 2001, pg 427). An alternative is to use one of the new ergonomic keyboards that are now available. With an ergonomic keyboard the keys are positioned to fit the operator's hands. The keys are placed on the board at an angle that allows the operator to keep the wrists straight. The keyboard surface is curved so that natural finger movements allow the operator to reach the correct keys. Finally, there is often a wrist support built into the keyboard (Kroemer, 2001, Ch 9).

When sit-down workstations are used, the chair becomes a very important piece of equipment. The ideal situation is the chair is full adjustable in all planes. The seat pan height is typically 37 to 50 cm above the floor. The height should be adjustable by means of a simple lever. The seat pan should also accommodate tilting and still be lockable in the normal position. The normal position is should be adjustable between +5 degrees and -30 degrees. The seat back should also be adjustable and will normally tilt backward at a 95 to 120 degree angle. This allows the user to set it for optimum comfort. The seat back should also provide lumbar support at 15 to 23 cm above the set pan and 38 to 42 cm from the front of the seat pan. Built in neck support should be 50 to 70 cm above the seat (Kroemer, 2001 pgs 432-434).

Figure 4 is an example of a newer chair type that is gaining popularity. The seat pan and back are made of a tightly stretched mesh material. This material provides support while giving enough to remain surprisingly comfortable. In addition, there is no foam to deteriorate over time and any airborne dirt particles tend to pass through the mesh. It seems to be a cleaner alternative for factory floor operations.

Figure 4

Workstation lighting is another important consideration. If the workstation is located in the factory such as a shipping area, then light levels should be adequate for the tasks at hand. The major concern is work station and monitor placement to eliminate glare from overhead lights, windows and work surfaces. By avoiding or eliminating glare, the workstation operator is more comfortable and productive.

If the workstation is located in a darkened area such as an office, then supplemental task lighting may be required. This task lighting should be set to illuminate critical areas such as the document feeder and keyboard locations. It should be positioned to eliminate glare and should not shine in the operators eyes.

The scanning equipment should be placed near the monitor and within easy reach of the operator. This will eliminate any excessive stretching and/or reaching movements.

The scanning equipment should be as simple to operate at possible. The best systems use software driven menus and are controlled from the computer. All actions from starting the scan to verifying the image, to storing the image in the correct server location should be done from the operator's station. The only functions that should require the operator to move away from the operator's station are loading scanner feed bin and collecting the documents after they have been scanned.

Software

The software represents the heart of the record scanning system. It captures the image then scan and indexes it to make retrieval possible at a later date. Software also provides the user interface needed to control the scanner, verify the scanned image and then store it in the correct storage location. The software must allow the operator to view and verify the scanned image. It should also be capable of reading bar code data, Optical Character Recognition (OCR) typed text or machine printed text scans and Intelligent Character Recognition (ICR) scans of cursive or freeform text such as handwriting on checks.

All of these requirements make software selection one of the most critical elements in building a efficient cost effective records management system. Several software packages from several different manufacturers will have to seamlessly work together in order to produce the desired results.

The scan engine works with the records management software. High quality capture software products such as Ascent Capture by Kofax are twain compliant, which enables them to work with a wide variety of scanners, regardless of manufacture. Add-on features such as Virtual ReScan (VRS) let the operator scan a stack of mixed documents (various sizes, printed on colored paper, photocopies, or carbons) with confidence that the best image possible is being produced. This makes scanning as simple as pressing the scan button (Kofax, nd).

The records management software provides the critical operator and user interface into the system. Industry leading packages such as Documentum by EMC and Laserfiche by LaserFiche make extensive use of icons and other graphical interfaces. They leverage the user's knowledge of Micro Soft Windows products to reduce the training time required for their products.

The records management software not only stores the scanned image, it also captures and stores the associated metadata, or data about data, required to locate the image at a later date. This metadata includes information on when the image was created, who created it, any pertinent indexing information, the image format, where the image is stored and in some cases the native program used to create the image. Without this information being readily available to the software, the user is relegated to a tedious manual search for the required information. Imagine a treasure hunt for an item that you cannot see or touch. It only becomes visible when viewed on a computer screen.

The records management software takes over this burden. It knows where the image is stored and quickly retrieves it with a few simple mouse clicks. By implementing a records management program, one aerospace company was able to reduce the records search time required as part of a first article inspection (FAI) by 87%. Part of the first article inspection process required the inspector to locate, copy and refile the material certifications and test reports for the materials and components that were incorporated into the product. In the past, this took an average of two hours per first article inspection. The records management system reduced this time to between 10 and 15 minutes per first article.

Along with the improved retrieval time, filing errors were eliminated. Since the image is electronic, the original is never removed from its storage location. The inspector simply attaches an electronic copy to the FAI file or prints a hardcopy when necessary. The refiling operation has been eliminated along with the tedium and boredom associated with any manual filing operation (Barrett, 2005).

Intelligent Character Recognition

Intelligent Character Recognition allows the scanning system to capture and read handwritten entries on a scanned page. This capability is important when scanning documents such as manufacturing tracers and invoices. It allows easier retrieval of records once they are scanned into the system.

Scott Balu provides significant insight into how the ICR system operates in his Datacap sponsored webinar titled *ICR 101 – Solving the Mystery of Handprint Recognition*. The ICR system uses neural network technology to recognize handwritten and machine printed text. The technology handles variability extremely well. This capability reduces the operator workload.

Simply put the technology uses a combination of context, predetermined formulas, rules and sometimes form design to solve the mystery of where a letter or number begins and what that letter or number is. The software scans the image and assigns a confidence level to each character. This results in four possible situations for each character.

- High confidence correct
- Low confidence correct
- Low confidence incorrect
- High confidence incorrect.

Depending on the accuracy requirements the operator establishes a confidence level threshold. If the confidence level is above the threshold, the character is not highlighted for operator attention. If the confidence level is below the threshold, then the character is highlighted to bring it to the operator's attention for review and possible correction. Used correctly, ICR can greatly reduce the operator's data verification workload and deliver accurate data faster and at less cost.

Conclusion

By paying close attention to the Human Factors Engineering elements of record retention, a company can significantly improve the working conditions for its employees. The goal should be to reduce or eliminate the elements of risk where ever they are found. Safety records can be improved and industrial insurance claims can be reduced by eliminating the need to manually handle 40 pound boxes of records with an electronic records management system. Add in the time and cost savings and the decision to convert is made even easier.

One final note, the company should ensure that its written policies support good Human Factors Engineering principles. The dangers associated with moving pallets of records were previously discussed. Company policy should require training for all forklift operators on each type of forklift they will operate. Records of this training should be kept.

Many companies contend that their workforce is their most valuable asset. By applying Human Factors Engineering principles to every aspect of the workplace, management proves the statement is more than just a cliché. The dollars spent on design, mitigation and new equipment are viewed as an investment in the workforce. One that is paid back through fewer L&I claims and higher worker productivity.

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