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EMERGENCY DESTRUCTION OF INFORMATION STORING MEDIA

APPENDIX I: ANALYSIS MATRIX

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December 1987

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Space and Naval Warfare Systems Command
and
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This IDA Report was prepared for the Commander, Space and Naval Warfare Sytems Command and the National Computer Security Center. It provides a basis for analyzing the appropriateness of various destruction technologies in the emergency destruction of information storing media. The support task was structured as a multi-year effort, with interim reports and updates, ultimately leading to a research plan for developing specific destruction techniques, equipment, and procedures. The prior interim reports are incorporated into this final iteration. The Report comprises three volumes: Emergency Destruction of Information Storing Media; Appendix I, Analysis Matrix; and Appendix II, Destruct Technology Compendium.

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Task T-Z5-341

SECTION A

MECHANICAL MUTILATION, cutting action

Generic Description of MECHANICAL MUTILATION, cutting action

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Equipment size varies by manufacturer and model. Units range in size from small desktop models to large, stand-alone devices occupying many square feet of floor space.

- Utility requirements
  Electrical power - cutting action equipment usually requires higher voltage (220 volts, three phase) and amperage. Since cutting action increases the volume of the destroyed material by at least a factor of five, high throughput volume units may require some mechanism for transporting the cut up waste away from the destruct equipment.

- Manpower requirements
  Generally, personnel are needed to access, remove, collect and transport the media to the shredder and feed them into the machine. Specific information storage media may affect how this task can be performed.

Safety Concerns

- Process
  Generally, the process poses no significant hazards. Cutting or pulverizing chromium dioxide magnetic recording media may release toxic constituents. Accessing and transporting specific media elements, in particular fixed media, may introduce hazards.

- Materials
  Shredding does not require any additional process-specific destruct materials. Materials hazards, if any, can only arise from the materials comprising the destroyed media.

- Accidental trigger
  Since destroying by mechanical mutilation requires the active steps of collecting and transporting the media to the shredding device, there is a low possibility of accidental trigger.

- Emergency environment
  Aside from the increased risk of performing any task under adverse conditions, the emergency environment does not present new or exacerbate existing hazards associated with the destruction process.

Risk of compromise

- Destruction speed
  Cutting action destroys material rapidly. Although the actual speed is determined by a combination of motor power and the final particle size, a single capacity load of material can usually be destroyed in less than 1 minute.

- Throughput
  Throughput is the quantity of material, usually measured in pounds, that can be destroyed per unit time. There are two critical elements of throughput: getting the media to the destruct equipment; and actually cutting up the media. The speed with which the material can be brought and fed to the equipment is site, manpower, and media specific. The actual cutting throughput is dependent on the horsepower of the machine, the input throat dimensions, the capacity of a single load, the mechanical properties of the medium (e.g., thickness, hardness), the destruction speed, and the number of destruct units available that can be used in parallel.

- Premature termination
  It is possible to terminate the cutting action prematurely by cutting off the electricity to the machine or causing the equipment to jam. Some rotary knife mills can be procured with a generator to supply electric power in the event of a power outage during the emergency. The process can also terminate prematurely if the equipment malfunctions. Such malfunctions are more likely on lower power, lower duty cycle machines that are forced to run at maximum capacity in an emergency.

- Destruction completeness
  Depends on specific equipment-medium factors. Cutting action produces a variety of particle sizes and shapes: strips, cross-cut strips, particles (rotary knife mills), and hammermill "dust". The size and shape of the shards, in conjunction with the storage density of the specific medium, determine the degree of destruction completeness.

- Detectability
  Mechanical mutilation is accompanied by some level of equipment noise. In particular, high power rotary knife mills tend to be very loud. As such, the fact that destruction is being carried out may be detected at some point outside the immediate vicinity of the destruct area.

- Information concentration
  Depends on specific medium and local facility factors. Information is usually spread throughout the facility. Information frequently will be concentrated in file cabinets, bookcases, tape racks, desk tops or internally throughout the information processing equipment. Since most information is rarely cataloged and stored by sensitivity category, a major task may be the identification and separation of highly sensitive information from less sensitive material.

- Medium accessibility
  Depends on specific medium, local facility and specific equipment factors. The difficulty and complexity of accessing media is set, in part, by the specific medium and whether it was designed to be fixed or removable. The removal of fixed media may be relatively complex and require special tools and training. Both fixed and removable media may be stored in secure containers or housings, which in turn may delay accessing the actual media.

State of Destruct Technology

Mechanical mutilation technology is highly evolved. A variety of products are available from numerous vendors. Some products have been tested and approved for DoD use for the destruction of classified documents. The list of such products is maintained and regularly updated by the National Security Agency.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Semiconductor, All Types

Effectiveness: Medium to Poor

Process:

The silicon die within the device package is broken into tiny fragments to preclude the recovery of information.

Destruction Issues:

System Overhead Concerns

- Manpower requirements
  Personnel are needed to access and remove circuit cards with memory components. If the cards are not removable, the semiconductor package must be separated from the circuit card. This procedure requires special tools and training. The circuit cards or components need to be transported to the destruct equipment and fed into the machine.

Safety Concerns

- Process
  Electrical shock is possible if information processing equipment is not powered down before personnel attempt to access memory elements. High voltage may be retained by some capacitors even after external power is removed.

Risk of compromise

- Destruction completeness
  Ranges from poor to excellent. Equipment that is designed to destroy circuit cards may result in individual fragments large enough to allow completely intact or significantly large fragments of the silicon die surviving the destruct process. Special investigative techniques can be used to extract the information content of the original memory from such fragments.

- Information concentration
  The information to be destroyed resides within device components of electronic equipment that may be dispersed throughout a facility. An additional dispersing effect arises from the difficulty of easily identifying and separating memory components from other device components. Furthermore, only memory components that have stored sensitive information need to be destroyed, but there is no easy method to identify those specific components.

- Medium accessibility
  Poor to very poor. The silicon die is mounted within a hermetically sealed component package, which is mounted along with other components on a circuit card. The circuit card, in turn, is mounted with other components and circuit cards onto a chassis and housed within a sealed cabinet. The cabinet itself may be further secured in an equipment rack, or with some other mounting scheme.

State of Destruct Technology

Most cutting action equipment is not appropriate for destroying semiconductor memories - the motors and cutting blades are simply not powerful enough to cut through the combination of ceramic, plastic, fiberglass and metal materials found on circuit cards. Some rotary knife mills (with motor ratings exceeding 3 horsepower) are powerful enough to handle complete circuit cards. This equipment, however, yields fragments that are large enough to permit complete semiconductor dies to be recovered following destruction. Smaller desktop units resembling blenders do a reasonable job of destroying the memory element, but require that the package be removed from the circuit card. Some even require that the silicon die be extracted from the package. Such labor and time intensive practices are not practical in an emergency environment.

Discussion:

Semiconductor memories are difficult to destroy with cutting action mechanical mutilation because the memories' tiny, high information storage density silicon dies are contained within so many successive housings. These containers add significantly to the total volume of material that must be destroyed to assure, to a high degree, that the actual silicon dies within them are adequately destroyed.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Recording, Tape, Reel-to-Reel

Effectiveness: Medium

Process:

The magnetic recording medium is cut into tiny fragments to randomize the information content and to preclude information recovery.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Medium. The degree of completeness depends on the final size of the shards. Half inch reel-to-reel tapes store information at densities up to 112 Kbits per square inch. At these densities, even shards 1/64 of an inch on a side contain about 27 bits. This amount of information corresponds to the equivalent of 3.5 letters of text or about half a word. Most cutting equipment does not achieve even this fine a particle size.

- Information concentration
  Tapes are frequently stored on racks in tape libraries or vaults. They also can be distributed throughout a facility: in desk drawers, in files, etc.

- Medium accessibility
  Tapes found at a facility may contain both sensitive and routine information. Unless the reels have security markings or the contents are indexed, identification and prioritization of tapes for destruction may be difficult. The medium is highly accessible unless stored in secure containers..

State of Destruct Technology

No shredders have been identified that specifically address the destruction of reels-to-reel tapes.

Discussion:

Facilities that utilize tapes for information storage also tend to generate large quantities of data. As such, tape libraries usually contain hundreds of reels of tape.

Cutting equipment's ability to destroy tapes may be affected by the reel material and the effect of the tapes themselves being tightly wound on reels. Some equipment may not have an input throat that can accept the almost one inch thick reels, or may not have sufficient cutting ability to cut through the mass of the Mylar and reel. The Mylar base of the tapes may cause gumming of the cutting mechanism.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Recording, Tape, Cartridges (Cassettes, Wafers)

Effectiveness: Medium to Poor

Process:

The magnetic recording medium is cut into tiny fragments to randomize the information content and to preclude information recovery.

Destruction Issues:

Safety Concerns

- Process

There has been some concern expressed that cutting action may release highly toxic hexavalent chromium compounds if the new chromium dioxide tapes are subjected to cutting action. Since chromium dioxide tapes are a new medium, there is little information on potential health hazards.

Risk of compromise

- Destruction completeness

Medium to poor. The degree of completeness depends on the final size of the shards. Half and quarter inch cartridge tapes store information at densities up to 1.4 Mbits per square inch. At these densities, even shards 1/64 of an inch on a side contain about 334 bits. This amount of information corresponds to the equivalent of 42 letters of text or about 2/3 of a printed line of text. Most cutting action equipment does not achieve even this fine a particle size.

- Information concentration

Tape media cartridges can be distributed throughout a facility: in desk drawers, in files, etc.

- Medium accessibility

Cartridges found at a facility may contain both sensitive and routine information. Unless the the containers have security markings or the contents are indexed, identification and prioritization of cartridges for destruction may be difficult. The medium is highly accessible unless stored in secure containers.

State of Destruct Technology

No equipment has been identified that specifically addresses the destruction of cartridge tapes.

Discussion:

The equipment's ability to destroy the actual tapes may be affected by the properties of the cartridge case material and the effect of the tapes themselves being tightly wound on hubs. Some cutting equipment may not have an input throat that can accept the almost one inch thick cartridges, or may not have sufficient cutting ability to cut through the mass of Mylar. The Mylar base of the tapes may cause gumming of the cutting mechanism. The quarter inch and some 0.15 inch cartridges contain a thick metal plate that may interfere with the cutting action. The new IBM half-inch cartridge contains large metal parts inside.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Recording, Floppy Disks

Effectiveness: Medium to Poor

Process:

The magnetic recording medium is cut into tiny fragments to randomize the information content and to preclude information recovery.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Medium to poor. The degree of completeness depends on the final size of the shards. Floppy disks are a relatively high density storage medium with densities up to 2 Mbits per square inch. At these densities, even shards 1/64 of an inch on a side contain almost 490 bits. This amount of information corresponds to the equivalent of 61 letters of text or about one printed line. Most cutting-based destruct equipment does not achieve even this fine a particle size.

- Information concentration
  Floppy diskettes are compact, rugged, and relatively portable. As such, they tend to be distributed throughout a facility: in desk drawers, in files, etc.

- Medium accessibility
  Floppy disks found at a facility may contain both sensitive and routine information. Unless the the disks have security markings or the contents are indexed, identification and prioritization of disks for destruction may be difficult. The medium is highly accessible unless stored in secure containers.

State of Destruct Technology

No equipment has been identified that specifically addresses the destruction of floppy disks.

Discussion:

The metal constituents and hard plastic shell of the 3-1/2 inch diskettes may present a problem to some lower power shredders. The thickness of soft jackets of the 5-1/4 and 8 inch diskettes should pose no problems for shredders. The Mylar base of the diskettes or plastic components of the jackets may cause gumming of the cutting mechanism.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Recording, Hard Disks, Removable

Effectiveness: Poor to Very Poor

Process:

The magnetic recording medium is cut into tiny fragments to randomize the information content and to preclude information recovery.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Poor to very poor. It is not expected that cutting action is a viable mechanism for destroying hard disks.

- Information concentration
  Hard disks tend to be stored in the proximity of the associated disk drive.

- Medium accessibility
  Medium is highly accessible unless stored in secure containers.

State of Destruct Technology

No equipment has been identified that is designed specifically for the destruction of removable hard disks.

Discussion:

Rotary knife mills are the only cutting devices that could handle the hard materials found in cartridges and disk packs. Rotary knife mills, however, cannot cut through the hub material of the 14 inch disk cartridges and packs Such cartridges and packs would have to be disassembled before destruction, and the hubs removed. Even after passing through the cutting mechanism, the individual shards of disk material still contain a significant amount of stored information (in excess of several pages of text) because of the high storage density of hard disks.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Recording, Hard Disks, Fixed

Effectiveness: Not applicable/practical

Discussion:

Fixed hard disks are mounted in user inaccessible, sealed containers. This, coupled with the inability of cutting action to adequately destroy removable hard disks, makes cutting action a non-viable method for fixed hard disk destruction in an emergency environment.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Recording, Drums

Effectiveness: Not applicable/practical

Discussion:

Magnetic drums consist of a metal drum that may present problems for shredder cutting mechanisms. The drum itself is difficult to access, and the cylindrical shape of the drum memory element may present problems for destruct equipment designed to accept flat material. It is speculated that some of the very high power rotary knife mills may be capable of destroying drums.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Current-Accessed (Core, Twistor, Plated Wire)

Effectiveness: Possibly Medium to High

Process:

The memory planes are physically destroyed by fragmenting and randomizing the individual components.

Destruction Issues:

System Overhead Concerns

- Manpower requirements
  Personnel are needed to access and remove memory array cards, transport them to, and feed them into the destruct machine. This procedure requires special tools and training.

Safety Concerns

- Process
  Electrical shock is possible if information processing equipment is not powered down before personnel attempt to access memory elements. High voltage may be retained by some capacitors even after external power is removed.

Risk of compromise

- Destruction completeness
  Excellent. Rotary knife mills designed to destroy circuit cards can destroy current-accessed magnetic memories. Equipment that does not have sufficient power to break apart the memory assembly leaves the information contents recoverable.

- Information concentration
  The information storing elements tend to reside in the main computing processor. The individual components are readily identifiable by their characteristic appearance.

- Medium accessibility
  Poor to very poor. The memory elements are within closed chassis and may be difficult to access. Furthermore, the physical removal of the memory planes may be difficult.

State of Destruct Technology

Current-accessed memories can be destroyed only by units powerful enough to handle complete circuit cards. These higher power units have motors in excess of 3 horsepower and specially hardened cutting blades.

Discussion:

Core, twistor, and plated wire memories are low density storage media and breaking them up into small fragments is an effective method of destroying their information content. The information content of core memories can be destroyed by simply separating the ferrite cores from the wire matrix. Since each core represents only one bit of stored information, physical randomization of the cores is sufficient to destroy the information content, even if the cores remain magnetized. The main concern for emergency destruction is whether the memories can be removed quickly from the equipment.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Magnetic, Bubble

Effectiveness: Possibly Medium to High

Process:

Either the bubble material die within the device package is broken into tiny fragments to preclude the recovery of information, or the vertical magnetic bias field source is separated from the package, causing the bubble domains to collapse.

Destruction Issues:

<u>System Overhead Concerns</u>

- Manpower requirements
  Personnel are needed to access and remove circuit cards with bubble memory components. If the cards are not removable, the bubble memory package must be separated from the circuit card. This procedure requires special tools and training. The circuit cards or components need to be transported to and fed into the machine.

<u>Safety Concerns</u>

- Process
  Electrical shock is possible if information processing equipment is not powered down before personnel attempt to access memory elements. High voltage may be retained by some capacitors even after external power is removed.

<u>Risk of compromise</u>

- Destruction completeness
  Possibly excellent. Rotary knife mills must have sufficient power and strong enough blades to destroy the bubble memory contents by breaking apart the memory module.

- Information concentration
  The information elements reside in electronic equipment, the various components of which may be dispersed throughout a facility. An additional dispersing effect arises from the difficulty of easily identifying and separating the specific memory components from the other electronic components.

- Medium accessibility
  Poor to very poor. The bubble memory, including the magnetic field generating elements, is mounted within a hermetically sealed component package, which is mounted along with other components on a circuit card. The circuit card, in turn, is mounted with other components and circuit cards onto a chassis and housed within a closed cabinet. The cabinet may be mounted in an equipment rack or further contained within a physical security housing.

State of Destruct Technology

Most shredders and hammermills are not appropriate for destroying bubble memories - the motors and cutting blades are simply not powerful enough to cut through the combination of ceramic, plastic, fiberglass and metal materials found on circuit cards, and comprising the bubble memory module. Most rotary knife mills are powerful enough to handle complete circuit cards and, therefore, bubble memory modules. These higher power units have motors in excess of 3 horsepower and specially hardened cutting blades.

Discussion:

Reports verifying the effectiveness of mechanical mutilation based on cutting action in destroying bubble memories have not been found. It is conjectured that the information content of bubble memories can be destroyed effectively with rotary knife mills if the rotary knife mill separates the bubble memory die from the permanent magnet in the module that supplies the bias field. Once this field is removed, the bubble domains collapse into the random, snake-like domains, thereby destroying the contents of the memory element. The actual effectiveness of this destruct technique needs to be verified by a field test.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Optical, Microform

Effectiveness: Medium to Poor

Process:

The microform film storage medium is cut into tiny fragments to randomize the information content and to preclude information recovery.

Destruction Issues:

Risk of compromise

- Destruction completeness

  Medium to poor. The degree of completeness depends on the final size of the shards. The equipment that pulverizes the medium or that forms confetti-like shards provides a reasonable degree of destruction. Shredders that cut the medium into strips leave the information largely recoverable.

- Information concentration

  Microforms are small and highly portable. Microfilm on reels tends to be housed in protective boxes and stored in special file cabinets. Microfiche are housed in protective paper sleeves and are likewise frequently stored in cabinets. Because they are flat and readily available in "user copies," microfiche tend to be distributed throughout a facility: in desk drawers, in files, etc.

State of Destruct Technology

Specific devices have been designed for destroying microforms. The plastic base of microforms has a tendency to gum and jam the cutting mechanisms of some equipment. Likewise, the reels and housing of microfilm rolls and cartridges may present problems (throat opening may not be large enough, or the shredders may not be capable of handling that material). If the film has to be removed from the reels or cartridges, throughput will be significantly reduced.

Discussion:

Sandia National Laboratories has performed an unpublished study on the amount of time necessary to reconstruct cut up microforms as a function of shard size and initial volume of material (degree of information randomization). Charles Clark, Reassembly of Microfiches After Destruction by a Dry Disintegrator, Sandia National Laboratories, December 1976.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Optical, Laser-Accessed

Effectiveness: Possibly Medium to Poor

Process:

The storage medium is cut into tiny fragments to randomize the information content and to preclude recovery by standard readout equipment.

Destruction Issues:

<u>Safety Concerns</u>

- Materials

The hazards of exposure to some of the optical storage materials themselves (e.g., tellurium compounds and alloys in the WORM type media) have not been thoroughly investigated. During normal medium use, these materials are encapsulated, and not likely to contact personnel. Cutting the medium apart may expose personnel to these materials with unknown health effects.

<u>Risk of compromise</u>

- Destruction completeness

Medium to poor. Laser-accessed optical storage media are extremely high density media. In the case of equipment that cuts the media into tiny pieces, the output shards, even 1/64 inch on the side, still contain considerable amounts of information; well in excess of the contents of a printed page of text. It is possible, however, that rotary knife mills may disintegrate the optical media sufficiently to preclude information recovery. More research in this area is necessary.

- Information concentration

Individual media elements (e.g., discs, tapes) can contain tremendous amounts of information in a relatively small volume. The individual media elements are highly portable and rugged. Thus, they can be stored in any manner consistent with facility security requirements.

- Medium accessibility

Medium is highly accessible unless stored in secure containers.

State of Destruct Technology

Laser-accessed optical storage is a new storage technology. As a result, the manufacturers of mechanical mutilation equipment have not yet addressed the problem of destroying laser-accessed storage media. Equipment capable of handling microforms should be capable of handling plastic substrate optical storage media. Glass or metal substrates may present a problem for many cutting action equipment types.

Discussion:

Laser-accessed optical storage media are not, as yet, widely distributed. This technology is experiencing rapid growth and shortly will be widely used.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Punched, Cards

Effectiveness: High

Process:

The computer card is cut into tiny fragments or strips to randomize the information content and to preclude information recovery.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Excellent. The low density of information storage makes cutting highly appropriate for computer card destruction.

- Information concentration
  Computer cards tend to be stored in file cabinets designed for their size, in cardboard boxes holding up to 2,000 cards, or in stacks simply bound with elastic bands. Although cards can be located virtually anywhere in a facility, they tend to be in discreet clusters.

- Medium accessibility
  Readily accessible unless stored in secure containers.

Discussion:

The relative thickness (99 pound paper) of the card stock may limit the possible cutting speed of lower power desk top shredders. Most equipment, however, should have no difficulty in destroying the medium. Manufacturers tend to identify specific models as more appropriate for computer card destruction.

Because computer cards are a low storage density medium, the physical volume of cards at a facility may be large. Furthermore, the computer card is an obsolete storage medium that is in the process of being phased out. More data is necessary to establish the actual quantity of cards that can be expected to be found at a facility.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Punched, Tape

Effectiveness: High

Process:

The punched tape is cut into tiny fragments or strips to randomize the information content and to preclude information recovery.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Excellent. The low density of information storage makes cutting action highly appropriate for punched tape destruction.

- Information concentration
  Punched tapes tend to be wound on reels up to 14 inches in diameter, stored as coils, or fanfolded in containers.

Discussion:

The reels themselves may present problems to some equipment. Therefore, it may be necessary to unwind the tape in order to destroy it. This, in turn, adds to the destruct time. Plastic tapes may gum up the cutting mechanisms of some shredders.

Destruct Method: MECHANICAL MUTILATION, cutting action

Storage Medium: Paper, All Types

Effectiveness: Medium to High

Process:

The paper is cut into tiny fragments or strips to randomize the information content and to preclude information recovery.

Destruction Issues:

Safety Concerns

- Process

Hammermills generate fine dust. The fine dust can explode if the proper mixture of air and dust is permitted to form. Such a mixture can be detonated with a spark or open flame. The effect is analogous to grain silo and flour mill dust explosions. Furthermore, high concentrations of dust can present a respiratory hazard.

Risk of compromise

- Destruction completeness

Poor to excellent. Rotary knife mills and shredders that produce crosscut particles provide an excellent degree of information destruction of text documents. Shredders that merely cut the paper into strips leave the information recoverable, albeit with a considerable degree of effort required on the adversaries' part. Shredders offer medium to poor destruction completeness of software strips due to their high density of information storage. Hammermills offer an excellent degree of destruction completeness for all paper media.

- Information concentration

Paper tends to be randomly distributed everywhere throughout a facility. Some degree of information concentration exists in the form of file cabinets and bookshelves.

- Medium accessibility

Readily accessible unless stored in secure containers. The major difficulty is not getting to the material itself, but rather, separating the sensitive material from the sheer volume of routine material.

Discussion:

Most strip and crosscut shredders are not harmed by occasional small metal pieces, such as staples or paper clips. Bound documents may present some problems to smaller shredders. The input throat may be able to accept only thin stacks of paper. As a result, bound documents may need to be broken apart and hard covers (such as ring binders) removed prior to destruction. Rotary knife mills have less of a problem with both metal constituents and bound documents.

Sandia National Laboratories has performed a study on the amount of time necessary to reconstruct shredded paper as a function of shard size and initial volume of material (degree of information randomization). Charles Clark and Alan Swain, Shredded Document Reassembly Study, SAND 76-0320, October 1976.

SECTION B

MECHANICAL MUTILATION, abrasive action

Generic Description of MECHANICAL MUTILATION, abrasive action

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  The process requires minimal equipment. The required abrasives are compact and easily stored. Hand-held power tools can be used to speed up the destruct process.

- Utility requirements
  Hand-held power tools require either electricity or batteries to operate.

- Manpower requirements
  Generally, personnel are needed to identify, access and remove the media. The destruct process is manual and is performed by personnel.

Safety Concerns

- Process
  Generally, the process poses no significant hazards. Abrasive action applied to chromium dioxide magnetic recording media may release toxic constituents. Accessing and transporting specific media elements, in particular fixed media, may introduce electrical shock hazards.

- Materials
  Abrasive action does not require any hazardous process-specific destruct materials. Materials hazards, if any, can only arise from the materials comprising the destroyed media.

- Accidental trigger
  Since destroying by mechanical mutilation requires the active steps of collecting or accessing the media, there is a low possibility of accidental trigger.

- Emergency environment
  Aside from the increased risk of performing any task under adverse conditions, the emergency environment does not present new or exacerbate existing hazards associated with the destruction process.

Risk of compromise

- Destruction speed
  Abrasive action is a slow process. Access to the appropriate part of the medium may take some time and the destruct process itself is labor intensive and time-consuming.

- Throughput
  The throughput is dependent on the specific medium and the skill of the personnel performing the task.

- Premature termination
  The personnel performing the destruct task can be interrupted and prevented from completing the process.

- Destruction completeness
  Depends on the skill and thoroughness of the personnel. Careless workmanship can leave patches of information storing media intact.

- Detectability
  The destruct process is not detectable from outside the immediate vicinity of the destruct area.

- Information concentration
  Depends on specific medium and local facility factors. Information frequently will be concentrated in file cabinets or bookcases. Since information is rarely cataloged and stored by sensitivity category, a major task may be the identification and separation of highly sensitive information from less sensitive material.

- Medium accessibility
  Depends on specific medium, local facility and specific equipment factors. The difficulty and complexity of accessing media is set, in part, by the specific medium, and whether it was designed to be fixed or removable. The removal of fixed media may be relatively complex and require special tools and training. Both fixed and removable media may be stored in secure containers or housings, which in turn may delay accessing the actual media.

State of Destruct Technology

Abrasive action is a crude, but effective, method of destroying information stored on fixed hard disks. Virtually any abrasive, such a sandpaper or cleaning scouring powder, can be applied manually or with a power tool, such as a power sander or grinding wheel. It is conjectured that abrasive action destruction could be a designed-in feature of some information storage equipment. Research is necessary to verify this possibility.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Semiconductor, All Types

Effectiveness: Not applicable/practical

Discussion:

Abrasive action would have to be applied directly to the surface of the silicon die which would have to be removed from its package. This elaborate procedure is not practical in an emergency environment.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Magnetic, Recording, Tape, Reel-to-Reel

Effectiveness: Not applicable/practical

Discussion:

Although abrasive action can remove the thin magnetic layer on tape media, the sheer length of the tape on reels renders this approach impractical due to the amount of time and effort required to accomplish destruction.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Magnetic, Recording, Tape, Cartridges (Cassettes, Wafers)

Effectiveness: Not applicable/practical

Discussion:

Although abrasive action can remove the thin magnetic layer on tape media, the sheer length of the tape in cartridges renders this approach impractical due to the amount of time and effort required to accomplish destruction.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Magnetic, Recording, Floppy Disks

Effectiveness: Medium

Process:

Both surfaces of the magnetic recording medium are subjected to abrasive action removing the thin, information storing magnetic recording layer.

Destruction Issues:

System Overhead Concerns

- Manpower requirements

  Personnel are needed to remove the protective jackets and shells to access the floppy disks themselves. Personnel must manually perform the actual destruct function.

Risk of compromise

- Destruction completeness

  Medium to high. The magnetic surface layer can be completely removed with abrasives. Careless workmanship, however, may leave patches of the information storing layer intact.

- Information concentration

  Floppy diskettes are compact and relatively portable. They do not require any special care or handling. As such, they tend to be distributed throughout a facility: in desk drawers, in files, etc.

- Medium accessibility

  Floppy disks found at a facility may contain both sensitive and routine information. Unless the disks have security markings or the contents are indexed, identification and prioritization of disks for destruction may be difficult. The medium is highly accessible unless stored in secure containers.

State of Destruct Technology

This is a manual process, not requiring any elaborate destruct equipment.

Discussion:

Abrasive action is a crude, but effective, method of destroying information stored on floppy disks. Virtually any abrasive, such a sandpaper or cleaning scouring powder, can be used. The main drawback of this technique is the time necessary to access the magnetic diskette itself and to completely abrade both surfaces. It is conjectured that a mechanism that would mechanically abrade the surface of a floppy disk could be included as part of a disk drive unit. The effectiveness and advisability of this approach requires further investigation.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Magnetic, Recording, Hard Disks, Removable

Effectiveness: Medium to High

Process:

Both surfaces of the magnetic recording medium are subjected to abrasive action removing the thin, information storing, magnetic recording layer.

Destruction Issues:

System Overhead Concerns

- Manpower requirements
  Personnel are needed to remove the hard disks from any protective shell or housing. Personnel must manually perform the actual destruct function.

Risk of compromise

- Destruction completeness
  Medium to high. The magnetic surface layer can be completely removed with abrasives. Careless workmanship, however, may leave patches of the information storing layer intact.

- Information concentration
  Hard disks tend to be stored in the proximity of the associated disk drive.

- Medium accessibility
  Medium is highly accessible unless stored in secure containers.

State of Destruct Technology

This is a manual process, not requiring any elaborate destruct equipment.

Discussion:

Abrasive action is a crude, but effective, method of destroying information stored on fixed hard disks. Virtually any abrasive, such a sandpaper or cleaning scouring powder, can be used. The main drawbacks of this technique are the time and effort necessary to access the magnetic disk itself and to completely abrade both surfaces. It is conjectured that a mechanism that would mechanically abrade the surface of a hard disk could be included as part of a disk drive unit. The effectiveness and advisability of this approach requires further investigation.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Magnetic, Recording, Hard Disks, Fixed

Effectiveness: Medium to Poor

Process:

Both surfaces of the magnetic recording medium are subjected to abrasive action removing the thin, information storing, magnetic recording layer.

Destruction Issues:

<u>System Overhead Concerns</u>

- Manpower requirements

  Personnel are needed to access the hard disks themselves. Since fixed disks are usually housed within hermetically sealed chassis, which are further housed in equipment racks and cabinets, this procedure requires special tools and training. Personnel must manually perform the actual destruct function.

<u>Safety Concerns</u>

- Process

  Electrical shock is possible if information processing equipment is not powered down before personnel attempt to access memory elements. High voltage may be retained by some capacitors even after external power is removed.

<u>Risk of compromise</u>

- Destruction completeness

  Medium to high. The magnetic surface layer can be completely removed with abrasives. Careless workmanship, however, may leave patches of the information storing layer intact.

- Information concentration

  Fixed hard disks are mounted integral to the information processing equipment or close to it (they need to be physically connected by a cable).

- Medium accessibility

  Medium is not accessible. The disk itself is housed in a sealed container which is then usually further mounted within other successive, difficult to access, enclosures.

State of Destruct Technology

This is a manual process, not requiring any elaborate destruct equipment.

Discussion:

Abrasive action is a crude but effective method of destroying information stored on fixed hard disks. Virtually any abrasive, such a sandpaper or cleaning scouring powder, can be used. The main drawbacks of this technique are the time and effort necessary to access the magnetic disk itself and to completely abrade both surfaces. It is conjectured that a mechanism that would mechanically abrade the surface of a hard disk could be included as part of a disk drive unit. The effectiveness and advisability of this approach requires further investigation.

Destruct Method: **MECHANICAL MUTILATION, abrasive action**

Storage Medium: **Magnetic, Recording, Drums**

Effectiveness: **Medium to High**

Process:

The thin magnetic surface coating of the drum is removed by mechanically abrading the surface.

Destruction Issues:

System Overhead Concerns

- Manpower requirements

  Personnel are needed to access the magnetic drums. This procedure requires special tools and training. Personnel must manually perform the actual destruct function.

Safety Concerns

- Process

  Electrical shock is possible if information processing equipment is not powered down before personnel attempt to access the magnetic drums. High voltage may be retained by some capacitors even after external power is removed.

Risk of compromise

- Destruction completeness

  Medium to high. The plated magnetic surface layer can be completely removed with abrasives. Careless workmanship, however, may leave patches of the information storing layer intact.

- Information concentration

  Magnetic drums are an old technology, and store information at a relatively low density. The drum storage unit is usually an integral part of the information processing equipment.

- Medium accessibility

  Poor. Magnetic drums rotate at a high speed, and therefore are housed within a sealed, protective enclosure. Accessibility is further reduced since the enclosed drum is usually mounted within chassis and equipment racks.

State of Destruct Technology

This is a manual process, not requiring any elaborate destruct equipment.

Discussion:

Abrasive action is a crude, but effective, method of destroying information stored on magnetic drums. Virtually any abrasive, such a sandpaper or cleaning scouring powder, can be used. The main drawback of this technique is the time necessary to access the drum itself and to completely abrade the surface of the drum.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Magnetic, Current-Accessed (Core, Twistor, Plated Wire)

Effectiveness: Not applicable/practical

Discussion:

There are no memory components that could be destroyed effectively with abrasive action.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Magnetic, Bubble

Effectiveness: Not applicable/practical

Discussion:

Although the bubble memory utilizes a thin surface layer of garnet on a substrate that could be destroyed by abrasion, this active layer is not readily accessible in order to apply the abrasive action. The amount of time that would be required to access and disassemble a bubble memory module in order to reach this active layer makes abrasive action impractical. Furthermore, in the process of disassembly, once the bias field permanent magnets are removed, the bubble domains collapse, destroying any stored information. As such, further disassembly to apply abrasive action is unnecessary.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Optical, Microform

Effectiveness: Medium to High (small volumes), Not applicable/practical (large volumes)

Process:

The emulsion of the microform film storage medium is removed with abrasive action.

Destruction Issues:

System Overhead Concerns

- Manpower requirements
  Personnel are needed to remove the microform media from protective jackets or rolls. Personnel must manually perform the actual destruct function.

Risk of compromise

- Destruction completeness
  Medium to high. The film emulsion layer can be completely removed with abrasives. Careless workmanship, however, may leave patches of the information storing layer intact.

- Information concentration
  Microforms are small and highly portable. Microfilm on reels tends to be housed in protective boxes and stored in special file cabinets. Microfiche are housed in protective paper sleeves and are likewise frequently stored in cabinets. Because they are flat and readily available in "user copies," microfiche tend to be distributed throughout a facility: in desk drawers, in files, etc.

State of Destruct Technology

This is a manual process, not requiring any elaborate destruct equipment.

Discussion:

Abrasive action is a crude, but effective, method of destroying information stored on microform media. Virtually any abrasive, such a sandpaper or cleaning scouring powder, can be used. The main drawback of this technique is the time necessary to completely abrade the surface.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Optical, Laser-Accessed

Effectiveness: Possibly Medium to High

Process:

The surface of the optical storing medium is subjected to abrasive action, removing the thin, information storing layer.

Destruction Issues:

Safety Concerns

- Materials

  The hazards of exposure to some of the optical storage materials themselves (e.g., tellurium compounds and alloys in the WORM type media) have not been thoroughly investigated. During normal medium use, these materials are encapsulated, and not likely to contact personnel. Abrading the medium surface may expose personnel to these materials with unknown health effects.

Risk of compromise

- Destruction completeness

  Possibly medium to high. Laser-accessed optical storage media store information in a thin layer near the surface. It is unknown how difficult it will be to abrasively penetrate the outer protective layers and to reach the information storing layer. More research in this area is necessary.

- Information concentration

  Individual media elements (e.g., discs, tapes) can contain tremendous amounts of information in a relatively small volume. The individual media elements are highly portable and rugged. Thus, they can be stored in any manner consistent with facility security requirements.

- Medium accessibility

  Medium is highly accessible unless stored in secure containers.

State of Destruct Technology

This is a manual process, not requiring any elaborate destruct equipment.

Discussion:

Laser-accessed optical storage media are not, as yet, widely distributed. It can be expected, however, that this technology will experience rapid growth and shortly will be in wide use. The possibility of using abrasive action to destroy optical disks should be investigated further.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Punched, Cards

Effectiveness: Not applicable/practical

Discussion:

Abrasive action is not an effective or efficient method for rapidly destroying the information content of paper-based media.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Punched, Tape

Effectiveness: Not applicable/practical

Discussion:

Abrasive action is not an effective or efficient method for rapidly destroying the information content of paper-based media.

Destruct Method: MECHANICAL MUTILATION, abrasive action

Storage Medium: Paper, All Types

Effectiveness: Not applicable/practical

Discussion:

Abrasive action is not an effective or efficient method for rapidly destroying the information content of paper-based media.

SECTION C

PULPING

Generic Description of PULPING

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  A pulping system consists of a tank, water extractor, input feeder and pulp output trough. The tank sizes range from 24 to 48 inches in diameter. The peripheral equipment is approximately the same size as the tank.

- Utility requirements
  Three phase electric power along with input and waste plumbing connections. For large volume applications, waste handling equipment also may be necessary.

- Manpower requirements
  Personnel are required to collect the media, transport them to the destruct equipment, and feed them into the device and remove waste.

Safety Concerns

- Process
  No significant hazards.

- Materials
  No significant hazards.

- Accidental trigger
  Low possibility of accidental trigger.

- Emergency environment
  Emergency environment does not present new or exacerbate existing hazards associated with destruction.

Risk of compromise

- Destruction speed
  Pulper operation is designed for continuous input of materials and the tank is not self-cleaning. As such, if an item is inserted into the unit, there is no set time in which all of the constituents of the item would pass through. The bulk of the item would pass through in less than a minute, but it is possible for some pieces (large enough to permit information recovery) to remain in the main tank for some time, or until more material is added which would help purge the tank.

- Throughput
  Different-sized units can destroy a maximum of 500 to 2,000 pounds of paper products per hour (since DoD level of security requires that the waste material pass through a finer screen than is acceptable for industrial sensitive material, the throughput is reduced and is 250 to 1,000 pounds per hour).

- Premature termination
  Possible to terminate prematurely by cutting off the electricity to the pulper. If the water supply is cut off, the pulper can continue to destroy media for a limited time with water that is recycled in the process. The water however "thickens" as minute particles that can not be separated out readily accumulate. During normal operation, fresh water is continually added at a rate of about 5 gallons per minute or more (depending on the unit size), while "stagnant" water is removed at a rate that maintains a constant water level.

- Destruction completeness
  Excellent. The semi-dry pulp is impossible to reconstruct.

- Detectability
  Pulping is not likely to be detectable from the outside.

- Information concentration
  Paper-based media tend to be randomly distributed everywhere throughout a facility. Some degree of information concentration exists in the form of file cabinets, desks and shelves.

- Medium accessibility
  Readily accessible unless stored in secure containers. The major difficulty is not getting to the material, but rather separating the sensitive material from the sheer volume of other material.

State of Destruct Technology

Pulping has been in use for over 25 years. The technology is mature and well-developed.

Discussion:

Pulping is particularly appropriate for the routine destruction of large volumes of paper-based material requiring a sustained throughput. Pulping cannot destroy plastics, metal and other non-paper materials. Therefore, plastic folders, binders, covers, etc. may interfere with the machine's operation.

Destruct Method: PULPING

Storage Medium: Semiconductor, All Types

Effectiveness: Not applicable/practical

Discussion:

Pulpers are inappropriate for destroying semiconductor memories. The destruct device would have no effect on the information content of a semiconductor memory, and it is likely that the memory device would damage the pulper itself.

Destruct Method: PULPING

Storage Medium: Magnetic, Recording, Tape or Floppy Disk or Card

Effectiveness: Not applicable/practical

Discussion:

The Mylar base of magnetic recording media is neither water soluble nor does it significantly soften in water. Therefore, the destruct mechanism utilized by pulpers is not completely effective at destroying these media. The impeller blades of the pulper tank will inflict some damage to the media, but the media will be insufficiently damaged to preclude information reconstruction. Furthermore, if large pieces of plastic are sucked against the sizing sieve, they may clog the water circulating mechanism. The metal and stiff plastic constituents of the media housing components also may damage the impeller blades.

A potential research payoff area is a "pulping" device that uses solvents that dissolve the particulate binder. The device could be a closed system with solvent-solute separation and recovery based on an integral distillation process. The resultant device would not be a true pulping device, but would contain some of the mechanical aspects of pulping coupled with chemical destruction.

Destruct Method: PULPING

Storage Medium: Magnetic, Recording, Hard Disk, Fixed or Removable

Effectiveness: Not applicable/practical

Discussion:

Pulpers are inappropriate for destroying hard disks. The hard metal disk substrate will damage the impeller blades and the pulper will accomplish only minimal destruction of the information stored on the disk.

Destruct Method: PULPING

Storage Medium: Magnetic, Recording, Drums

Effectiveness: Not applicable/practical

Discussion:

Pulpers are inappropriate for destroying magnetic drums. The hard metal substrate will damage the impeller blades and the pulper will accomplish only minimal destruction of the information stored on the drum.

Destruct Method: PULPING

Storage Medium: Magnetic, Current-Accessed

Effectiveness: Not applicable/practical

Discussion:

Pulpers are inappropriate for current-accessed magnetic memories. The hard metal components and wires will damage the impeller blades and could jam the pulper.

Destruct Method: PULPING

Storage Medium: Magnetic, Bubble

Effectiveness: Not applicable/practical

Discussion:

Pulpers are inappropriate for destroying magnetic bubble memories. The destruct device would have not effect on the information content of a bubble memory unless the impeller blades happened to separate the perpendicular bias field permanent magnets from the device package. It is more likely, however, that the memory device would damage the pulper itself.

Destruct Method: PULPING

Storage Medium: Optical, Microform

Effectiveness: Not applicable/practical

Discussion:

The plastic base of microform media is neither water soluble nor does it significantly soften in water. Therefore, the destruct mechanism utilized by pulpers is not completely effective at destroying these media. The impeller blades of the pulper tank will inflict some damage to the media, but the media will be insufficiently damaged to preclude reconstruction. Furthermore, if large pieces of plastic are sucked against the sizing sieve, they may clog the water circulating mechanism. The metal and stiff plastic constituents of microform reels and cartridges also may damage the impeller blades.

A potential research payoff area is a "pulping" device that uses solvents that dissolve the image retaining photographic emulsion. The device could be a closed system with solvent-solute separation and recovery based on an integral distillation process. The resultant device would not be a true pulping device, but would contain some of the mechanical aspects of pulping coupled with chemical destruction.

Destruct Method: PULPING

Storage Medium: Optical, Laser-Accessed

Effectiveness: Possibly not applicable/practical

Discussion:

Pulpers are probably inappropriate for destroying laser-accessed optical memories. Although laser-accessed optical storage is an evolving technology with no dominant product type as yet, none of the products that already have appeared on the market are softened or dissolved by water. Furthermore, the plastic, glass or metal substrates could damage the pulper itself.

Destruct Method: PULPING

Storage Medium: Punched, Cards

Effectiveness: High

Process:

Paper punched cards are fed into a pulping tank, where a rotating impeller with integral cutters creates a vortex, pulling the material against the cutters and forcing the resultant slurry through a perforated sizing ring. The slurry is then passed through an extractor which removes excess water, discharging a semi-dry pulp and recycling the water.

Destruction Issues:

<u>Risk of compromise</u>

- Throughput

  Different-sized units can destroy a maximum of 500 to 2,000 pounds of paper products per hour (since DoD level of security requires that the waste material pass through a finer screen than is acceptable for industrial sensitive material, the throughput is reduced and is 250 to 1,000 pounds per hour).

- Destruction completeness

  Excellent. The semi-dry pulp is impossible to reconstruct.

- Information concentration

  Computer cards tend to be stored in file cabinets designed for their size, in cardboard boxes holding up to 2,000 cards, or in stacks simply bound with elastic bands. Although cards can be located virtually anywhere in a facility, they tend to be in discreet clusters.

State of Destruct Technology

Pulping has been in use for over 25 years. The technology is mature and well-developed.

Discussion:

The relative thickness (99 pound paper) of the card stock presents no problem to pulpers. Because computer cards are a low storage density medium, the physical volume of cards at a facility may be large. Furthermore, the computer card is an obsolete storage medium that is in the process of being phased out. More data is necessary to establish the actual quantity of cards that still can be expected to be found at a facility.

Destruct Method: PULPING

Storage Medium: Punched, Tape

Effectiveness: High (paper)
Not applicable/practical (plastic)

Process:

Paper punched tape is fed into a pulping tank, where a rotating impeller with integral cutters creates a vortex, pulling the material against the cutters and forcing the resultant slurry through a perforated sizing ring. The slurry is then passed through an extractor which removes excess water, discharging a semi-dry pulp and recycling the water.

Destruction Issues:

Risk of compromise

- Throughput
  Different-sized units can destroy a maximum of 500 to 2,000 pounds of paper products per hour (since DoD level of security requires that the waste material pass through a finer screen than is acceptable for industrial sensitive material, the throughput is reduced and is 250 to 1,000 pounds per hour).

- Destruction completeness
  Excellent. The semi-dry pulp is impossible to reconstruct.

- Information concentration
  Punched tapes tend to be wound on reels up to 14 inches in diameter, stored as coils, or fanfolded in containers.

State of Destruct Technology

Pulping has been in use for over 25 years. The technology is mature and well-developed.

Discussion:

Tape that is stored on reels must be removed from the reels before the tape can be destroyed. This, in turn, adds to the destruct time. Oiled tapes present no problem to pulpers. Plastic tapes cannot be destroyed by pulpers.

Destruct Method: PULPING

Storage Medium: Paper, All Types

Effectiveness: High

Process:

Paper media are fed into a pulping tank, where a rotating impeller with integral cutters creates a vortex, pulling the material against the cutters and forcing the resultant slurry through a perforated sizing ring. The slurry is then passed through an extractor which removes excess water, discharging a semi-dry pulp and recycling the water.

Destruction Issues:

Risk of compromise

- Throughput
  Different-sized units can destroy a maximum of 500 to 2,000 pounds of paper products per hour (since DoD level of security requires that the waste material pass through a finer screen than is acceptable for industrial sensitive material, the throughput is reduced and is 250 to 1,000 pounds per hour).

- Destruction completeness
  Excellent. The semi-dry pulp is impossible to reconstruct.

- Information concentration
  Paper tends to be randomly distributed everywhere throughout a facility. Some degree of information concentration exists in the form of file cabinets and bookshelves.

- Medium accessibility
  Readily accessible unless stored in secure containers. The major difficulty is not getting to the material, but rather separating the sensitive material from the sheer volume of other material.

State of Destruct Technology

Pulping has been in use for over 25 years. The technology is mature and well-developed.

Discussion:

Pulping is particularly appropriate for the routine destruction of large volumes of material requiring a sustained throughput. Pulping's ability to destroy plastics, metal and other non-paper materials is limited. Although occasional plastic materials, such as folders, binders, covers etc., will not damage a pulper, these materials are not adequately destroyed, and larger quantities may clog the sizing screen.

A portable pulping mechanism is described in U. S. Patent 3,688,708 - Transporter Case, granted September 5, 1972. The mechanism consists of a container housing the "water soluble paper" documents, a pouch of water and effervescent tablets. Upon trigger, the water comes in contact with the paper, while the tablets generate turbulence which breaks up the documents. The patent has been assigned to the

General Signal Corp., Rochester, N.Y., and it is unclear whether the product was ever manufactured.

SECTION D

EXPLOSION

Generic Description of EXPLOSION

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Explosives can be mounted integral to the information storing equipment. A small quantity of explosive can generate a shock wave that can impart significant damage to information storing media. Since the shock wave can cause structural damage to the surrounding facility or personnel, some method for containing the physical force of the explosion is necessary.

- Utility requirements
  Explosions can be initiated without any external utility constraints.

- Manpower requirements
  Generally, explosives would be mounted integral to the storage medium well in advance of the emergency situation. As such, personnel are needed only to arm the detonating trigger mechanism and initiate the explosion. If the explosives are not integral to the equipment, personnel would be required to access, emplace and detonate the explosive charges. Significant expertise would be necessary on the part of these personnel to assure that the explosives are emplaced in a manner that would, in fact, destroy all the media to a degree that would preclude information recovery.

Safety Concerns

- Process
  Improper use of explosives may cause structural damage to the facility and/or injury to the personnel.

- Materials
  Although they are inherently dangerous, explosive materials can be selected and packaged in a manner that minimizes the hazards associated with using, transporting and storing them. Some localities where platforms may operate expressly prohibit explosive materials within their jurisdiction.

- Accidental trigger
  Configurations that place the media and explosives within the same device and allow detonation upon some trigger are candidates for accidental trigger. If the media has to be collected and transported to a common point, or if the explosives have to be emplaced, then the probability of accidental trigger is low.

- Emergency environment
  If the explosive material is housed inside the equipment, the emergency environment should present no increased hazard. The emergency environment, however, may exacerbate the hazards of handling explosives, or may cause the operator not to follow all safety precautions.

Risk of compromise

- Destruction speed
  Once detonation is initiated, destruction is instantaneous. If explosives have to be emplaced prior to detonation, the time necessary to achieve destruction is significantly increased.

- Throughput
  Throughput depends on the number of units that must be detonated independently within the facility. Generally, any number of destruct units can be wired together and triggered simultaneously.

- Premature termination
  Once detonation is triggered, termination is not possible. Prior to detonation, the triggering mechanism may be disabled.

- Destruction completeness
  Generally excellent. The explosives can usually be configured so that the medium is completely destroyed.

- Detectability
  If the amount of explosive necessary to accomplish destruction is low, and if the explosion can be contained within the equipment cabinet, the noise associated with destruction can be muffled. Large quantities of explosives, or explosives that are not contained within a muffling enclosure, will generate a shock wave that can be felt and heard outside the immediate vicinity.

- Information concentration
  Media that are appropriate for destruction with explosives tend to have a high information density and be in discrete clusters.

- Medium accessibility
  Media accessibility is not an issue if the information storing equipment has premounted, pre-wired explosive charges inside. Accessibility becomes an issue if explosive charges have to be emplaced.

State of Destruct Technology

Explosive destruct technology has been developed only for limited applications and situations.

Destruct Method: EXPLOSION

Storage Medium: Semiconductor, All Types

Effectiveness: High

Process:

Explosive force is used to break apart the silicon die within the device package.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics

  Sufficient explosives to destroy the appropriate semiconductor devices can be mounted within the information processing equipment. Some internal reinforcement or protective shielding of the equipment may be necessary to prevent injury to personnel upon detonation.

Risk of compromise

- Destruction completeness

  Excellent. The explosive mechanism can be designed so that the semiconductor die is completely destroyed.

- Detectability

  The amount of explosive necessary to accomplish destruction is low, and since the explosion is contained within the equipment cabinet, the noise associated with destruction is rather muffled.

- Information concentration

  The information to be destroyed resides within device components of electronic equipment that may be dispersed throughout a facility. If the explosives are mounted within appropriate units so as to destroy the proper component, the effect of information dispersal is minimal.

State of Destruct Technology

The technology for explosively destroying individual semiconductor memory components, while they are mounted within an equipment chassis, has been demonstrated.

Discussion:

The principal method for explosively destroying semiconductor memory devices consists of mounting small quantities of explosive material on a plexiglass sheet and placing the sheet in close proximity to the circuit board containing the memory chips to be destroyed. The explosive charges are positioned on the plexiglass such that they are directly in line with the chips to be destroyed. A small metal plate, about the size of a dime, is placed on the plexiglass between the explosive and the semiconductor chip and in contact with the explosive. Detonator wires connect the individual explosive charges and terminate in a pair of electrical connectors. Detonation can be accomplished with either a battery powered or a hand-pumped detonator. Upon detonation, the explosive "throws" the metal "flying plate" into the semiconductor package, creating an impulse (of 20 to 40 kilobars) that completely destroys the silicon die within the package. This setup destroys both the information stored on the chip and the technical information embodied in the chip itself. Provided there is sufficient room within the equipment chassis, this type of destruct mechanism can be retrofitted into existing or off-the-shelf equipment.

Destruct Method: EXPLOSION

Storage Medium: Magnetic, Recording

Effectiveness: Unknown

Discussion:

The effectiveness of explosives at destroying magnetic recording media is unknown. In general, it is conjectured that explosives can be used either to blow apart a medium (a form of mechanical mutilation by cutting) or to drive abrasive particles against the recording surface (a form of mechanical mutilation with abrasives). Since magnetic recording media are a rather high density storage technology, it is unknown whether the fragments, after the medium is blown apart, will be small enough to prevent information reconstruction. Likewise, it is unknown if the explosively driven abrasive action would be sufficiently thorough so that there would be no patches of undisturbed media surface remaining.

Destruct Method: EXPLOSION

Storage Medium: Magnetic, Current-Accessed (Core, Twistor, Plated Wire)

Effectiveness: Possibly Medium to High

Process:

Explosive force is used to physically destroy the memory planes by separating, fragmenting and randomizing the individual components.

Destruction Issues:

Risk of compromise

- Destruction completeness

  Medium to excellent. Depends on degree to which the individual memory storage location elements are separated from the matrix.

- Information concentration

  The information to be destroyed resides within memory planes housed within electronic equipment that may be dispersed throughout a facility. If the explosives are mounted within appropriate units so as to destroy the proper component, the effect of equipment dispersal is minimal.

State of Destruct Technology

Unknown.

Discussion:

It is conjectured that core and other current addressed memory storage devices can be effectively destroyed by explosive charges housed within the equipment.

Destruct Method: EXPLOSION

Storage Medium: Magnetic, Bubble

Effectiveness: High

Process:

Explosive force is used to break the permanent magnet providing the bias field away from the bubble memory module.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Sufficient explosives to break apart a bubble memory module can be mounted within the information processing equipment. Some internal reinforcement or protective shielding of the equipment may be necessary to prevent injury to personnel upon detonation.

Risk of compromise

- Destruction completeness
  Excellent. The explosives can be configured so that both the bias field magnets are separated from the module and the bubble material die itself is damaged.

- Detectability
  The amount of explosive necessary to accomplish destruction is low, and if the explosion is contained within the equipment cabinet, the noise associated with destruction is rather muffled.

- Information concentration
  The information to be destroyed resides within device components of electronic equipment that may be dispersed throughout a facility. If the explosives are mounted within appropriate units so as to destroy the proper component, the effect of information dispersal is minimal.

State of Destruct Technology

Unknown.

Discussion:

Explosive force can be effective at separating the permanent magnet from the module causing the magnetic domains to collapse. Practically, however, there are better, more effective techniques for destroying the information content of a bubble memory device, and it is doubtful that explosives would be the technique of choice.

Destruct Method: EXPLOSION

Storage Medium: Optical, All Types

Effectiveness: Unknown

Discussion:

The effectiveness of explosives at destroying optical storage media is unknown. In general, it is conjectured that explosives can be used either to blow apart a medium (a form of mechanical mutilation by cutting) or to drive abrasive particles against the information storing surface (a form of mechanical mutilation with abrasives). Optical storage media, especially laser-accessed media, are a rather high density storage technology. It is unknown whether the fragments, after the medium is blown apart, will be small enough to prevent information reconstruction. Likewise, it is unknown if the explosively driven abrasive action would be sufficiently thorough that there would be no patches of undisturbed media surface remaining.

Destruct Method: EXPLOSION

Storage Medium: Punched, All Types

Effectiveness: Medium to High

Process:

Explosive force is used to cause the media to disintegrate.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Medium to excellent. Depends on specific implementation, but complete destruction possible.

- Detectability
  If not adequately muffled, the explosion shock wave may be heard or felt on the outside.

- Information concentration
  Computer cards tend to be stored in file cabinets designed for their size, in cardboard boxes holding up to 2,000 cards, or in stacks simply bound with elastic bands. Although cards can be located virtually anywhere in a facility, they tend to be in discreet clusters. Punched tapes tend to be wound on reels up to 14 inches in diameter, stored as coils, or fanfolded in containers.

- Medium accessibility
  Readily accessible unless stored in secure containers. The major difficulty is not getting to the material itself, but rather, separating the sensitive material from the sheer volume of routine material.

State of Destruct Technology

No devices specifically designed to destroy punched media have been identified.

Discussion:

Punched media are a relatively low density storage medium. Therefore, from the perspective of accomplishing a high degree of destruction completeness, explosive force is highly appropriate. The main difficulty, however, arises from the volume of punched media that can be expected to be found at a facility. To destroy a large quantity of media, a proportionately large quantity of explosives would be required. This, in turn, increases the overall level of danger associated with the destruct process.

Destruct Method: EXPLOSION

Storage Medium: Paper, All Types

Effectiveness: Medium to High

Process:

Explosive force is used to cause the media to disintegrate.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Medium to excellent. Depends on specific implementation, but complete destruction possible.

- Detectability
  If not adequately muffled, the explosion shock wave may be heard or felt on the outside.

- Information concentration
  Paper tends to be randomly distributed everywhere throughout a facility. Some degree of information concentration exists in the form of file cabinets and book shelves.

- Medium accessibility
  Readily accessible unless stored in secure containers. The major difficulty is not getting to the material itself, but rather, separating the sensitive material from the sheer volume of routine material.

State of Destruct Technology

Sandia National Laboratory has actually designed, tested and fielded an explosive-based briefcase document carrier that allows the rapid destruction of paper in the event of an emergency. The device consists of a lightweight metal container, into which up to 50 sheets of paper are placed. A thin sheet of explosive is placed among the sheets of paper. When the explosive is detonated, it drives the paper against and through a metal honeycomb. In passing through the honeycomb, the paper is cut into small fragments, which then randomize on the other side of the honeycomb.

Another method is described in U. S. Patent 3,732,830 - Security Method and Device, issued May 15, 1973, and assigned to the United States (Army). The patented scheme consists of a honeycomb sheet with shaped charge explosives in each of the thousands of tiny cells. When triggered, the shaped charges drive the liner material into the paper, effectively shredding it.

Discussion:

Explosive force is most appropriate for destroying small discrete quantities of highly sensitive paper media. It is not expected that explosive force is appropriate for destroying all the sensitive paper media that could be located at a facility.

SECTION E

CHEMICAL ACTION

Generic Description of CHEMICAL ACTION

Destruction Issues:

<u>System Overhead Concerns</u>

- Physical Characteristics
  The equipment allowing the use chemicals for destroying information media varies by media type. Generally, the media can be placed into a container with the appropriate chemicals, or the chemicals can somehow be dispensed directly onto the media. The former approach requires some type of vat that is resistant to the chemicals and a method for storing the chemicals. The latter may utilize some permutation of piping, pumping, or other method for delivering the chemicals to the medium. The chemicals must be stored and, if they have a limited shelf life, replaced as necessary.

- Utility requirements
  Many of the chemicals that can be used to destroy media emit noxious or dangerous fumes. As such, some form of forced ventilation may be necessary.

- Manpower requirements
  If media are to be placed into a vat filled with the appropriate chemicals, then personnel are needed to access, remove, collect, transport and place the media into the container. The proper chemicals will have to be identified, transported and poured into the vat. Specific information storage media configurations may affect how this task can be performed. In systems that dispense the chemicals onto the media, personnel may have to load the chemicals into a central dispenser and then trigger the delivery mechanism.

<u>Safety Concerns</u>

- Process
  Destruction by chemical action may be quite hazardous. Some of the materials that can be used in destruction are themselves hazardous; likewise, in the process of destruction, the associated chemical reactions may result in dangerous by-products. Possible hazards include toxic fumes, personnel contact hazards, and explosive constituents.

- Materials
  Numerous hazardous materials are good candidates for accomplishing destruction. Mineral acids can cause severe burns if allowed to contact skin, can result in blindness if allowed to contact eyes, and can damage the mucous membranes of the lungs and nasal passages if their fumes are inhaled. Inhalation of organic solvent vapors can cause headaches, dizziness and even the loss of consciousness. Long term exposure to solvents, such as could be encountered in repeated drills or training sessions, can cause liver damage and some forms of cancer. The solvents are frequently highly flammable, and the accumulation of vapors may lead to an explosion. Tetra hydro furan, a potential candidate for dissolving magnetic recording media binders, forms unstable explosive peroxides if stored for a long time.

- Accidental trigger
  Configurations that place the media and chemicals within the same device and allow the two to mix upon some trigger are candidates for accidental trigger.

- Emergency environment
  The emergency environment seriously exacerbates the hazards associated with chemical action destruction. Many of the possible destruct materials are highly flammable, and can explode if open flames or gunfire is present. Furthermore, the speed required during emergency destruction may cause personnel to spill or otherwise come in contact with dangerous chemicals.

Risk of compromise

- Destruction speed
  Highly variable. The destruction speed depends on the specific medium-chemical combination, the configuration of the media (e.g., whether it is tightly rolled or flat), the relative concentration of the chemicals, their temperature and the degree of agitation.

- Throughput
  Throughput can be partitioned into two elements: the efficiency of getting the chemicals in contact with the media and the effectiveness of the chemical action. The speed with which the chemicals can be brought in contact with the appropriate materials depends on the specific chemical dispensing method or the method of getting the media to the chemicals. The effectiveness of the chemical action is medium-chemical combination specific.

- Premature termination
  It is possible to terminate chemical action by diluting the chemical or neutralizing its effectiveness (e.g., neutralizing an acid with a base).

- Destruction completeness
  Depends on specific chemical-medium factors.

- Detectability
  Chemical action may produce odors or fumes that could be detected from outside the immediate vicinity of the destruct effort.

- Information concentration
  Depends on specific medium-facility factors. Information frequently will be concentrated in file cabinets or bookcases. Since information is rarely cataloged and stored by sensitivity category alone, a major task may be the identification and separation of highly sensitive information from less sensitive material.

- Medium accessibility
  Depends on specific medium-facility-equipment factors. The difficulty and complexity of accessing media is set, in part, by the specific medium and whether it was designed to be fixed or removable. The removal of fixed media may be relatively complex and may require special tools and training. Both fixed and removable media may be stored in secure containers or housings, which in turn may delay accessing the actual media. In situations where a chemical dispensing mechanism is built integral to the equipment, accessibility is not a major factor.

State of Destruct Technology

There are very few products that employ chemical action to destroy media. This area presents opportunities for research.

Destruct Method: CHEMICAL ACTION

Storage Medium: Semiconductor, All Types

Effectiveness: Not applicable/practical

Discussion:

There are two aspects to the chemical destruction of semiconductor memories: penetrating the device package housing the actual memory die, and destroying the semiconductor memory element itself. Semiconductor memory elements are supplied in a wide variety of packages, both in terms of physical configuration and material composition. There exists no universal chemical that can rapidly attack and destroy all the possible varieties of semiconductor packaging materials. The organic solvents that possibly can dissolve some of the common plastic package types, have no effect on the semiconductor die. Furthermore, the processed silicon die itself is resistant to most chemicals except for the strongest acids, such as hydrofluoric acid. Hydrofluoric acid can destroy a silicon die, but has no effect on most plastic materials. Hydrofluoric acid is also extremely hazardous, and contact with skin may result in permanent skin ulcers. As a final note, if a two-step process is used, a thin plastic residue coating left by the dissolved package could actually have the effect of protecting the die from subsequent attack by the acid.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Recording, Tape, Reel-to-Reel

Effectiveness: Possibly Medium to High

Process:

The tape is subjected to chemicals that dissolve the Mylar substrate or particle binder.

Destruction Issues:

<u>System Overhead Concerns</u>

- Manpower requirements
  Personnel are required to collect the media, transport them to the destruct equipment, separate the tapes from the reels, and place them into the container. In addition, the chemicals must be poured or otherwise brought into contact with the media, and the mixture agitated to assist the chemical action.

<u>Risk of compromise</u>

- Destruction completeness
  Excellent, provided the chemicals are able to contact the tape surface. If the tape is left wound on reels, the chemicals may fail to reach the actual media surfaces. Removing the tape from the reels enhances the destruct process.

- Information concentration
  Tapes are frequently stored on racks in tape libraries. They also can be distributed throughout a facility: in desk drawers, in file cabinets, etc.

- Medium accessibility
  Tapes found at a facility may contain both sensitive and routine information. Unless the reels have security markings or the contents are indexed, identification and prioritization of tapes for destruction may be difficult. The medium is highly accessible unless stored in secure containers.

State of Destruct Technology

No existing systems were identified, but it should be possible to implement the technology after some initial research to identify the most appropriate chemicals and dispensing system configurations.

Discussion:

Organic chemicals, such as tetra hydro furan (THF) or dimethyl sulfoxide (DMSO), are most appropriate candidates for tape destruction. Such chemicals may attack the organic binder holding the ferrite particles to the Mylar. The exact chemical combination that is effective at attacking the binder depends on the specific proprietary binder formulation used by a manufacturer. Due to such binder variations, some chemicals may successfully attack the binder of one brand of media, yet leave another brand intact. Some manufacturers are reportedly using electron beam curing of the binder, which leaves the medium more resistant to chemical attack. Although mineral acids, such as hydrochloric acid or nitric acid, may cause the Mylar to swell slightly or may corrode the ferrite particles, it is unknown if such damage is sufficient to preclude information recovery. Mylar is a very stable and chemically resistant polyester. No chemicals that rapidly attack Mylar were identified.

A tape cutter consisting of an arbor-type press with a cutting blade and a hub for mounting the reel of tape has been developed at the NSA. The reel is mounted on the hub and the arbor handle is pulled bringing down the blade. The blade cuts across the width of the tape causing it to fall off the reel in short lengths.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Recording, Tape, Cartridges (Cassettes, Wafers)

Effectiveness: Possibly Medium to High

Process:

The magnetic recording medium within the cartridge or cassette is subjected to chemicals that dissolve the Mylar substrate or particle binder.

Destruction Issues:

System Overhead Concerns

- Manpower requirements

  The tape within a cartridge or cassette may need to be unwound, or the housing broken open. In addition, the chemicals must be poured or otherwise brought into contact with the media, and the mixture agitated to assist the chemical action.

Risk of compromise

- Destruction completeness

  Expected to be medium to high. The active recording layer is very thin and, therefore, the material can be dissolved rapidly. Destruction speed is affected by the chemicals' ability to access the tape surface itself. Cartridge and cassette housings can delay the chemicals in reaching the medium. Furthermore, once the chemical penetrates the housing, it still must reach the tape surface to attack the information storing surface areas. Since the tapes are tightly wound within the housing, the chemicals may be prevented from reaching the information storing medium surface.

- Information concentration

  Cartridges can be distributed throughout a facility: in desk drawers, in files, etc.

- Medium accessibility

  Cartridges found at a facility may contain both sensitive and routine information. Unless the containers have security markings or the contents are indexed, identification and prioritization of cartridges for destruction may be difficult. The medium is highly accessible unless stored in secure containers.

State of Destruct Technology

No existing systems were identified, but it should be possible to implement the technology after some initial research to identify the most appropriate chemicals and methods for dispensing them.

Discussion:

Organic chemicals, such as tetra hydro furan (THF) or dimethyl sulfoxide (DMSO), are most appropriate candidates for tape destruction. Such chemicals may attack the organic binder holding the ferrite particles to the Mylar. The exact chemical combination that is effective at attacking the binder depends on the specific proprietary binder formulation used by a manufacturer. Due to such binder variations, some chemicals may successfully attack the binder of one brand of media, yet leave another brand intact. Some manufacturers are reportedly using electron beam curing of the binder, which leaves the medium more resistant to chemical attack. Although mineral acids, such as hydrochloric acid or nitric acid, may cause the Mylar to swell slightly or may corrode the ferrite particles, it is unknown if such damage is sufficient to preclude information recovery. Mylar is a very stable and chemically resistant polyester. No chemicals that rapidly attack Mylar were identified.

The wide variety of tape cartridge case designs (standards merely specify form, fit function, and not the exact cartridge configuration) and formats means that a universal tool for rapidly separating the tape from the cartridge may be difficult to design. Such a tool, however, would significantly simplify destruction by chemical and other means, and therefore, represents a potential high-payoff research area.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Recording, Floppy Disks

Effectiveness: Possibly High

Process:

The floppy disk is subjected to chemicals that dissolve the Mylar substrate or particle binder, thereby destroying the information content.

Destruction Issues:

Risk of compromise

- Destruction speed
  Expected to be high. The record layer is very thin and therefore can be dissolved quickly. The major factors in destruction speed are the protective jackets and sleeves. They can delay the solvent in reaching the medium itself.

- Destruction completeness
  Expected to be excellent. The only concerns are the protective jackets and sleeves that may prevent the solvent from reaching the medium.

- Information concentration
  Floppy diskettes are inexpensive, compact and relatively portable. They do not require any special care or handling. As such, they tend to be present in large quantities and distributed throughout a facility: in desk drawers, in files, etc. However, they are generally found in the proximity of the disk drive units.

- Medium accessibility
  Floppy disks found at a facility may contain both sensitive and routine information. Unless the the diskettes have security markings, or the contents are indexed, identification and prioritization of diskettes for destruction may be difficult. The medium is highly accessible unless stored in secure containers.

State of Destruct Technology

No existing systems were identified, but it should be possible to implement the technology after some initial research to identify the most appropriate chemicals and dispensing system configurations.

Discussion:

Organic chemicals, such as tetra hydro furan (THF) or dimethyl sulfoxide (DMSO), are most appropriate candidates for floppy disk destruction. Such chemicals may attack the organic binder holding the ferrite particles to the Mylar. The exact chemical combination that is effective at attacking the binder depends on the specific proprietary binder formulation used by a manufacturer. Due to such binder variations, some chemicals may successfully attack the binder of one brand of media, yet leave another brand intact. Some manufacturers are reportedly using electron beam curing of the binder, which leaves the medium more resistant to chemical attack. Although mineral acids, such as hydrochloric acid or nitric acid, may cause the Mylar to swell slightly or may corrode the ferrite particles, it is unknown if such damage is sufficient to preclude information recovery. Mylar is a very stable and chemically resistant polyester. No chemicals that rapidly attack Mylar were identified.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Recording, Hard Disk, Removable

Effectiveness: Possibly Medium to High

Process:

The disk is subjected to substances that either chemically react with the aluminum substrate, and the plated magnetic surface layer, or dissolve the magnetic particle binder.

Destruction Issues:

Risk of compromise

- Destruction completeness
  Expected to be excellent. Some disk media may have a very thin protective surface layer that may determine the specific chemical combinations that would be effective.

- Information concentration
  Removable hard disks tend to be stored in close proximity to the disk drive. Due to their relatively high storage capacity and cost, there usually are not that many hard disks at a facility.

- Medium accessibility
  Some cartridge designs may limit the accessibility of the actual disk medium.

State of Destruct Technology

No existing systems were identified, but it is likely that the technology can be implemented following some research into optimal chemical combinations.

Discussion:

There are two major types of fixed hard disk media: particulate layer and plated layer. The particulate layer consists of ferrite particles held onto the disk surface with an organic binder. Plated disks consist of a very thin layer of magnetic metal that has been electroplated onto a metal substrate.

The chemicals that would be appropriate for hard disk destruction depend on the disk type and the aspect of the medium to be affected. Organic solvents, such as tetra hydro furan or dimethyl sulfoxide, may dissolve the organic binder holding the ferrite particles to the platter. The exact chemical combination that is effective at attacking the binder depends on the specific proprietary binder formulation used by a manufacturer. Due to such binder variations, some chemicals may successfully attack the binder of one manufacturer's medium, yet leave another manufacturer's medium intact. Mineral acids, such as sulfuric, hydrochloric or nitric acid, react with aluminum - the most common metal substrate - and with the metal constituents of plated layers. Mineral acids do not affect most plastics or the organic binder materials. More exotic acids, such as trifluoro acetic acid, affect both metals and plastics, but their specific effect on binder formulations is unknown.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Recording, Hard Disk, Fixed

Effectiveness: Possibly Medium to High

Process:

The disk is subjected to substances that chemically react with the aluminum substrate, the plated magnetic surface layer, or dissolve the magnetic particle binder.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics

  Most likely, the chemicals would be placed integral to the disk drive unit. Alternatively, the chemicals could be stored at one location and in an emergency brought to the media either by personnel or via a network of pipes, valves and pumps.

- Manpower requirements

  Personnel may be required to identify the appropriate disk drive unit and trigger the destruct mechanism, or alternatively, to transport the chemicals to the storage device manually or via a piping mechanism.

Safety Concerns

- Accidental trigger

  Depends on the specific implementation. If the destruct mechanism is mounted integral to the disk drive unit, accidental trigger is possible. If the chemicals are brought to the disk drive unit and in some manner dispensed to bring the storage medium in contact with the chemicals, the possibility of accidental trigger is much lower.

Risk of compromise

- Destruction speed

  Expected to be high. The particulate oxide recording layer is very thin and the entire binder can be dissolved very rapidly. Likewise, on plated media, the magnetic recording layer is very thin and can be eaten away rapidly by acids. Aluminum reacts very strongly with acids.

- Throughput

  Destruction could be accomplished on a disk drive by disk drive basis, or alternatively, on all disk drives simultaneously in response to a central trigger. If the destruct system is well designed and allows the personnel to get the chemical in contact with the medium rapidly, throughput is simply limited by personnel's ability to trigger the destruct mechanism.

- Destruction completeness

  Expected to be excellent, provided the chemical is able to contact the disk surfaces. Some disk media may have a very thin protective surface layer that may determine the appropriate choice of chemicals.

- **Information concentration**
  Fixed hard disks are mounted integral to the information processing equipment or close to it (they need to be physically connected by a cable).

- **Medium accessibility**
  Medium is not accessible. The disk itself is housed in a sealed container which is then usually further mounted within other successive, difficult to access, enclosures.

State of Destruct Technology

No existing systems were identified, but it should be possible to implement the technology after some initial research to identify the most appropriate chemicals and dispensing system configurations.

Discussion:

There are two major types of fixed hard disk media: particulate layer and plated layer. The particulate layer consists of ferrite particles held onto the disk surface with an organic binder. Plated disks consist of a very thin layer of magnetic metal that has been electroplated onto a rigid substrate.

The chemicals that would be appropriate for hard disk destruction depend on the disk type and the aspect of the medium to be affected. Organic solvents, such as tetra hydro furan or dimethyl sulfoxide, may dissolve the organic binder holding the ferrite particles to the platter. The exact chemical combination that is effective at attacking the binder depends on the specific proprietary binder formulation used by a manufacturer. Due to such binder variations, some chemicals may successfully attack the binder of one manufacturer's medium, yet leave another manufacturer's medium intact. Mineral acids, such as sulfuric, hydrochloric or nitric acid, react with aluminum - the most common rigid substrate - and with the metal constituents of plated layers. Mineral acids do not affect most plastics or the organic binder materials. More exotic acids, such as trifluoro acetic acid, affect both metals and plastics.

Fixed hard disks are not readily user-accessible. As such, the time that would be required to access the medium in order to place it into some container of chemicals for destruction makes the removal of the disk media impractical for emergency destruction. Therefore, any chemical destruction mechanism for fixed hard disks would have to have a mechanism for dispensing the chemical directly into the disk drive and would have to be externally triggerable.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Recording, Drum

Effectiveness: Possibly Medium to High

Process:

The drum is subjected to substances that chemically react with the plated magnetic surface layer and/or dissolve the magnetic particle binder.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Most likely, the chemicals would be placed integral to the drum drive unit. Alternatively, the chemicals could be stored at one location and in an emergency brought to the media either by personnel or via a network of pipes, valves and pumps.

- Manpower requirements
  Personnel may be required to identify the appropriate drive unit and trigger the destruct mechanism, or alternatively, to transport the chemicals to the storage device manually or via a piping mechanism.

Safety Concerns

- Accidental trigger
  Depends on the specific implementation. If the destruct mechanism is mounted integral to the drive unit, accidental trigger is possible. If the chemicals are brought to the drive unit and in some manner dispensed to bring the storage medium in contact with the chemicals, the possibility of accidental trigger is much lower.

Risk of compromise

- Destruction speed
  Expected to be high. The particulate oxide recording layer is very thin and the entire binder can be dissolved very rapidly. Likewise, on plated drums, the magnetic recording layer is very thin and can be eaten away rapidly by acids.

- Destruction completeness
  Expected to be excellent, provided the chemical is maintained in contact with the drum surface.

- Information concentration
  Magnetic drums are mounted either integral to the information processing equipment or very close to it (they need to be physically connected by a cable).

State of Destruct Technology

No existing destruct devices using this process were identified.

Discussion:

There are two major types of drum surfaces: particulate layer and plated layer. The particulate layer consists of ferrite particles held onto the drum surface with an organic binder. Plated drums consist of a very thin layer of magnetic metal that has been electroplated onto a cylindrical substrate.

The chemicals that would be appropriate for drum destruction depend on the disk type and the aspect of the medium to be affected. Organic solvents, such as tetra hydro furan or dimethyl sulfoxide, may dissolve the organic binder holding the ferrite particles to the drum. The exact chemical combination that is effective at attacking the binder depends on the specific proprietary binder formulation used by a manufacturer. Due to such binder variations, some chemicals may successfully attack the binder of one manufacturer's medium, yet leave another manufacturer's medium intact. Mineral acids, such as sulfuric, hydrochloric or nitric acid, react with drum substrates and with the metal constituents of plated layers. Mineral acids do not affect plastics or the organic binder materials. More exotic acids, such as trifluoro acetic acid, affect both metals and plastics.

Magnetic drums are not readily user-accessible. As such, the time that would be required to access the medium in order to place it into some container of chemicals for destruction makes removal of the drum media impractical for emergency destruction. Therefore, any chemical destruction mechanism for magnetic drums would have to have a mechanism for dispensing the chemical directly into the drum unit and would have to be externally triggerable.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Current-Accessed (Core, Twistor, Plated Wire)

Effectiveness: Not applicable/practical

Discussion:

Although acids can readily attack the metal constituents of core, plated wire or twistor memories, because of the difficulty of accessing these media and getting the acid to contact the appropriate elements, other destruct techniques are far better destruct candidates for these media.

Destruct Method: CHEMICAL ACTION

Storage Medium: Magnetic, Bubble

Effectiveness: Not applicable/practical

Discussion:

Bubble memories are packaged as an integral, hermetically sealed unit containing permanent magnets for the bias field. They also have drive coils for the rotating in-plane field in addition to the bubble material die itself. There is no simple combination of chemicals that would rapidly penetrate the packaging and react with the die.

Destruct Method: CHEMICAL ACTION

Storage Medium: Optical, Microform

Effectiveness: High

Process:

The microform film storage medium is subjected to substances that dissolve the image containing layer.

Destruction Issues:

Risk of compromise

- Destruction completeness

  High. The information storing emulsion layer can be completely removed from the plastic base.

- Information concentration

  Microforms are small and highly portable. Microfilm on reels tends to be housed in protective boxes or cartridges and stored in special file cabinets. Microfiche are housed in protective paper sleeves and are likewise frequently stored in cabinets. Because they are flat and readily available in "user copies," microfiche tend to be distributed throughout a facility: in desk drawers, in files, etc.

State of Destruct Technology

Small chemical destruct units are presently available. These units are primarily for the destruction of diazo and vesicular microfiche.

Discussion:

The emulsion layer of exposed silver halide films is composed of silver particles suspended in gelatin. The gelatin dissolves quickly in hot water -- the emulsion layer will completely dissolve in about 30 seconds in water that is 50 C. The polyester base is very stable and is not readily dissolved by organic solvents.

The thin emulsion of diazo or vesicular films dissolves almost instantaneously in acetone, methyl ethyl ketone, and methylene chloride. Other organic solvents may likewise dissolve the emulsion layer. Individual sheets of film are destroyed rapidly. Stacked sheets must be separated by paper or other absorbent material that draws the solvent to all parts of the individual sheet surfaces. Without such separators, the solvent only affects the emulsion near the outer edges of the stack. The chemical action at the edges effectively welds or seals the edges and prevents the solvent from reaching the interior of the stack.

The reels and housing of microfilm rolls and cartridges may delay the chemicals' ability to reach the microform itself. As with stacked sheets, rolled film prevents the solvent from reaching the inner surfaces. Since the film has to be removed from the reels or cartridges for destruction, throughput may be significantly affected. Some form of universal tool for rapidly separating the film from the reel would be helpful to this and other destruct methods.

Destruct Method: CHEMICAL ACTION

Storage Medium: Optical, Laser-Accessed

Effectiveness: Unknown

Discussion:

Laser-accessed information storage is a new and rapidly evolving technology. As such, no dominant product types have yet evolved. Media configurations are still highly proprietary and experimental. Without specific details as to media construction and materials (e.g., metal, plastic, glass), it is difficult to predict if and how chemical action would be effective at destroying the media information content. It can be conjectured that PMMA (poly methyl methacrylate) substrates will be dissolved by chlorinated organic solvents such as methylene chloride, glass substrates will be dissolved by hydrofluoric acid, and metal substrates by mineral acids. It is difficult to conjecture what chemicals would merely strip away the information storing layers.

Destruct Method: CHEMICAL ACTION

Storage Medium: Punched, Cards

Effectiveness: Poor

Process:

The punched cards are subjected to substances that chemically react with the paper.

Destruction Issues:

Risk of compromise

- Destruction speed

  Dependent on the specific chemicals, their concentration, the ambient temperature, the degree of agitation and quantity of media to be destroyed. Since destruction proceeds through contact with the surface, cards in the interior of a stack are not chemically attacked until the chemical can actually reach their surface. This in turn affects the destruction speed.

- Destruction completeness

  Medium to poor. Since punched cards are a low density information storage medium, a large quantity of chemicals would be necessary to destroy the number of cards expected to be found at a facility. Furthermore, since information is represented as punched out holes in the cards, the cards must be totally dissolved to ensure information destruction.

- Information concentration

  Computer cards tend to be stored in file cabinets designed for their size, in cardboard boxes holding up to 2,000 cards, or in stacks simply bound with elastic bands. Although cards can be located virtually anywhere in a facility, they tend to be in discreet clusters.

State of Destruct Technology

No existing destruct devices using this process were identified.

Discussion:

Chemical action may be appropriate only for relatively small quantities of punched card media. Destruction of large quantities of material may not be practical due to the quantity of chemicals required, the thickness of computer card paper, and the need to bring the chemicals into actual contact with the medium surface for the reaction to proceed.

The cellulose constituent of paper is very susceptible to acid hydrolysis. Hot, concentrated sulfuric acid is the best acid for attacking the cellulose. Upon contact with sulfuric acid, paper turns brown almost immediately and is reduced into a gel-like mass in a matter of minutes. Other acids, such as nitric acid and hydrochloric acid, will hydrolyze cellulose, but are not nearly as effective as sulfuric acid. The heat to enhance the chemical attack of cellulose can be generated easily by adding a small amount of water to the acid. In the process of dilution, sulfuric acid and other mineral acids generate a considerable amount of heat.

Cellulose is not as susceptible to alkaline hydrolysis. During the manufacture of paper, the cellulose is actually cooked in a solution of sodium hydroxide (a strong alkali) and sodium sulfide. Thus, alkalis are not good candidates for paper destruction.

Destruct Method: **CHEMICAL ACTION**

Storage Medium: **Punched, Tape**

Effectiveness: **Poor**

Process:

The punched tape is subjected to substances that either chemically react with the paper base tapes or dissolve the Mylar base tapes.

Destruction Issues:

System Overhead Concerns

- Manpower requirements

  Personnel are required to collect the media, transport them to the destruct equipment, and place them into the container. Tapes may need to be unwound from reels. In addition, the chemicals must be poured or otherwise brought into contact with the media, and the mixture agitated to assist the chemical action.

Risk of compromise

- Destruction completeness

  If the chemicals are allowed to totally hydrolyze the paper tape, complete destruction is possible. The oil content of some tapes may affect wetting and, therefore, the destruct process effectiveness.

- Information concentration

  Computer punched tapes tend to be wound on reels up to 14 inches in diameter, stored as coils, or fanfolded in containers.

State of Destruct Technology

No existing destruct devices using this process were identified.

Discussion:

Chemical action may be appropriate only for relatively small quantities of media. Destruction of large quantities of material may not be practical due to the quantity of chemicals that would be required, and the need to bring the chemicals into actual contact with the medium for the chemical action to take place.

Paper and mylar tapes would require different destruct chemicals. The cellulose constituent of paper punch tape is susceptible to acid hydrolysis. Hot, concentrated sulfuric acid is the best acid for attacking the cellulose. Upon contact with sulfuric acid, paper turns brown almost immediately and is reduced into a gel-like mass in a matter of minutes. Other acids, such as nitric acid and hydrochloric acid, will hydrolyze cellulose, but are not nearly as effective as sulfuric acid. The heat to enhance the chemical attack of cellulose can be generated easily by adding a small amount of water to the acid. In the process of dilution, sulfuric acid and other mineral acids generate a considerable amount of heat.

Cellulose is not as susceptible to alkaline hydrolysis. During the manufacture of paper, the cellulose is actually cooked in a solution of sodium hydroxide (a strong alkali) and sodium sulfide. Thus, alkalis are not good candidates for paper destruction.

Mylar is very stable and resistant to chemical attack. A specific solvent that would attack Mylar effectively has not been identified.

Destruct Method: CHEMICAL ACTION

Storage Medium: Paper, All Types

Effectiveness: Possibly Medium

Process:

The paper is subjected to chemicals that react with the paper, causing it to disintegrate and thereby obliterate the information content.

Destruction Issues:

<u>Risk of compromise</u>

- Destruction speed

  Depends on the specific chemicals, their concentration, the ambient temperature, the degree of agitation, the quantity of paper to be destroyed, and the specific properties of the paper. Since the destruct process requires the chemical to wet the paper, individual sheets will be destroyed much more quickly than stacks or bound volumes that impede the chemical's ability to get to the paper. Coatings on some papers may likewise impede the chemical action.

- Destruction completeness

  Possibly high. Provided that a sufficient quantity of chemical is brought into contact with the media, complete destruction is possible.

- Information concentration

  Paper tends to be randomly distributed everywhere throughout a facility. Some degree of information concentration exists in the form of file cabinets.

State of Destruct Technology

No existing destruct devices using this process were identified.

Discussion:

Chemical action may be appropriate for relatively small quantities of paper media. Destruction of large quantities of material may not be practical due to the quantity of chemicals required and the relative slowness of the process in reaching the interior pages of bound documents.

The cellulose constituent of paper is very susceptible to acid hydrolysis. Hot, concentrated sulfuric acid is the best acid for attacking the cellulose. Upon contact with sulfuric acid, paper turns brown almost immediately and is reduced into a gel-like mass in a matter of minutes. Other acids, such as nitric acid and hydrochloric acid, will hydrolyze cellulose, but are not nearly as effective as sulfuric acid. The heat to enhance the chemical attack of cellulose can be generated easily by adding a small amount of water to the acid. In the process of dilution, sulfuric acid and other mineral acids generate a considerable amount of heat.

Cellulose is not as susceptible to alkaline hydrolysis. During the manufacture of paper, the cellulose is actually cooked in a solution of sodium hydroxide (a strong alkali) and sodium sulfide. Thus, alkalis are not good candidates for paper destruction.

SECTION F

ERASING

Generic Description of ERASING

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  The equipment that erases media can be either integral to the information processing equipment, or can be a separate device. Erase equipment that is integral to the information processing equipment presents no additional overhead concerns based on its physical characteristics. The physical characteristics of external erase equipment depend on the manufacturer and equipment type.

- Utility requirements
  Depend on the specific equipment configuration. Some types of equipment require electric power.

- Manpower requirements
  In systems that utilize erase equipment that is external to the information processing system, personnel are needed to access, remove, collect and transport the media to the erasing equipment, to load the media, and then to operate the erasing equipment. Specific information storage media may affect how this task can be performed. In information processing systems configured with an internal erase capability, the erase process may be initiated by some form of command or trigger, and may proceed without further human intervention. With removable media, however, personnel may have to first access, remove, collect and transport the media to the information processing equipment, and then mount the media onto the equipment and operate the equipment.

Safety Concerns

- Process
  Generally, the process poses no significant hazards.

- Materials
  Erasing requires no hazardous materials.

- Accidental trigger
  Configurations where the erase mechanism is part of the information processing equipment may be vulnerable to accidental trigger. Likewise, media storage containers which also have media erase capabilities may be vulnerable to accidental trigger.

- Emergency environment
  Aside from the increased risk of performing any task under adverse conditions, the emergency environment does not present new or exacerbate existing hazards associated with the destruction process.

Risk of compromise

- Destruction speed
  Highly variable. The destruction speed depends on the specific characteristics of the erase equipment, the type of medium, and the quantity of media. Media can be erased by subjecting them to either a bulk erase process or a process whereby each individual "memory" location is individually accessed and then erased. The former can be quite rapid, the latter can be much slower.

- Throughput
  Throughput can be partitioned into two elements: the efficiency of transporting, loading, and otherwise preparing the media to the level that the erasing equipment can act upon it; and the quantity of magnetic media that can be processed in a single erase cycle. Both the speed with which the erase equipment can be brought to bear on the media and the speed of the erase process depend on facility-medium-equipment factors.

- Premature termination
  It is possible to terminate prematurely by stopping the erase process before it has deleted the stored information sufficiently to preclude information recovery. Depending on the specific equipment configuration, this may be accomplished by physically removing the medium from the equipment, or by shutting off the electric power.

- Destruction completeness
  Depends on specific erase technology-medium factors. Some erase processes leave a slight remnant of the information that had been stored.

- Detectability
  Generally, erasure cannot be detected from outside the immediate vicinity of the destruct effort.

- Information concentration
  Depends on specific medium-facility factors. Information frequently will be concentrated in file cabinets or bookcases. Since information is rarely cataloged and stored by sensitivity category, a major task may be the identification and separation of highly sensitive information from less sensitive material.

- Medium accessibility
  Depends on specific medium-facility-equipment factors. The difficulty and complexity of accessing media is set, in part, by the specific medium, and whether it was designed to be user-accessible. Accessing media that is an integral component of the information processing equipment may be relatively complex, and may require special tools and training. If such media can be erased without removal by a process that is a feature of the equipment , then accessibility is not a significant factor. If the media must be removed in order to erase them, then accessibility may play a major role. Facilities may have procedures and practices whereby certain user-accessible media are stored in secure containers or housings, which in turn may delay accessing the actual media.

State of Destruct Technology

Sophisticated erase methods have been developed and implemented for some media.

Destruct Method: ERASING

Storage Medium: Semiconductor, ROM

Effectiveness: Not applicable/practical

Discussion:

ROMs are programmed during the semiconductor fabrication process. There is no way for these devices to be field erased.

Destruct Method: ERASING

Storage Medium: Semiconductor, RAM

Effectiveness: High

Process:

The memory contents are overwritten to some predetermined value, or are simply lost when power is disconnected.

Destruction Issues:

<u>System Overhead Concerns</u>

- Physical Characteristics
  Usually exists as a feature of the information processing equipment.

- Utility requirements
  Power may be necessary, although in most cases the loss of power will clear the memory contents.

<u>Safety Concerns</u>

- Accidental trigger
  The memory contents can be accidentally erased if the "erase" command is accidentally entered, or the power to the information processing equipment equipment is removed.

<u>Risk of compromise</u>

- Destruction speed
  The entire contents of a RAM semiconductor memory can be completely erased in less than a second.

- Throughput
  Depends on the personnel's ability to access and power down all the various equipment at a facility, or to enter the appropriate "erase" commands..

- Premature termination
  Sometimes possible if the equipment is powered back up almost immediately and the memory contents have not yet decayed sufficiently (most systems, however, will clear the memory upon power up).

- Destruction completeness
  Very good. The memory contents are erased, but under some conditions, the prior memory contents can actually be retrieved, albeit with elaborate equipment and procedures.

- Information concentration
  The information is located within the integrated circuits that are soldered onto circuit cards comprising the information processing equipment. As such, equipment containing RAMs can be distributed throughout a facility. Furthermore, compact portable equipment may contain RAM semiconductor memory circuits and it may be difficult to find this equipment rapidly in an emergency.

- Medium accessibility
  Not an issue, since the "erase" command would be issued either through the normal input keyboard or via some form of "panic" button.

State of Destruct Technology

Proven and existing technology.

Discussion:

RAMs are considered to be volatile memories, and under most circumstances, the RAM components of an information processing system memory will lose their contents as soon as external power to the equipment is removed. Some RAMs, however, are made by including special tiny batteries inside the device package. These batteries provide just enough standby current to retain the memory contents after the external power is removed. Similarly, some system designs include small, rechargeable batteries on the same circuit card as the memory components that supply the requisite power after system power is removed. Therefore, it should not be assumed that just because a memory element is a RAM component that it is in fact volatile.

Destruct Method: ERASING

Storage Medium: Semiconductor, PROM

Effectiveness: Not applicable/practical

Discussion:

PROMs are field programmed using special equipment that addresses the appropriate memory cell and applies current that burns out a fusible link and "sets" the memory contents. Although these devices can be field programmed so that all the memory locations are set to the same value, this process must be accomplished by first removing the PROM from its circuit, and then placing it into a special instrument for programming such devices. This procedure is too time consuming, and therefore is impractical for emergency destruction.

Destruct Method: ERASING

Storage Medium: Semiconductor, EPROM

Effectiveness: Not applicable/practical

Discussion:

EPROMs can be bulk erased using intense ultra-violet light. The EPROM device to be erased is removed from the circuit and placed in an EPROM eraser that illuminates the silicon die through the quartz window provided in the device package. A typical eraser can hold about 10 EPROMs and requires that the EPROM be exposed to the ultra-violet light for about 45 minutes. An erased EPROM still contains some remnant signal indicative of the previously stored information. Although this signal does not interfere with the subsequent writing of new information, with proper instrumentation and probing techniques, the prior information content can be deduced. Therefore, due to the long erasure time and the remnant signal, erasure is not a viable method for emergency destruction of information stored on an EPROM.

Destruct Method: ERASING

Storage Medium: Semiconductor, EEPROM

Effectiveness: High

Process:

The memory contents are overwritten to some predetermined value.

Destruction Issues:

<u>System Overhead Concerns</u>

- Physical Characteristics
  Usually exists as a feature of the information processing equipment.

- Utility requirements
  External power is necessary.

<u>Safety Concerns</u>

- Accidental trigger
  The memory contents can be accidentally erased if the "erase" command is accidentally entered.

<u>Risk of compromise</u>

- Destruction speed
  The entire contents of an EEPROM semiconductor memory can be completely erased in less than a second.

- Throughput
  Depends on the personnel's ability to enter the appropriate "erase" commands.

- Premature termination
  Unknown - probably not possible once "erase" command is executed.

- Destruction completeness
  Very good. The memory contents are erased, but under some conditions, the prior memory contents actually can be retrieved, albeit with elaborate equipment and procedures.

- Information concentration
  The information is located within the integrated circuits that are soldered onto circuit cards comprising the information processing equipment. As such, equipment containing EEPROMs can be distributed throughout a facility. Furthermore, compact portable equipment may contain EEPROM semiconductor memory circuits and it may be difficult to find this equipment rapidly in an emergency.

- Medium accessibility
  Not an issue, since the "erase" command would be issued either through the normal input keyboard or via some form of "panic" button.

State of Destruct Technology

Proven and existing technology.

Discussion:

EEPROMs store information by transferring electric charge to a "floating" gate. As a result, even after erasure, there may still be a remnant charge which may be measured to determine the memory contents prior to erasure. Since such measurements would require elaborate equipment and expertise, it can be assumed that the risk of compromise from such analysis is rather low.

Destruct Method: ERASING

Storage Medium: Semiconductor, NOVRAM

Effectiveness: High

Process:

The memory contents are overwritten to some predetermined value.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Usually exists as a feature of the information processing equipment.

- Utility requirements
  External power is necessary.

Safety Concerns

- Accidental trigger
  The memory contents can be accidentally erased if the "erase" command is accidentally entered.

Risk of compromise

- Destruction speed
  The entire contents of an NOVRAM semiconductor memory can be completely erased in less than a second.

- Throughput
  Depends on the personnel's ability to enter the appropriate "erase" commands.

- Premature termination
  Unknown - probably not possible once "erase" command is executed.

- Destruction completeness
  Very good. The memory contents are erased, but under some conditions, the prior memory contents actually can be retrieved, albeit with elaborate equipment and procedures.

- Information concentration
  The information is located within the integrated circuits that are soldered onto circuit cards comprising the information processing equipment. As such, equipment containing NOVRAMs can be distributed throughout a facility. Furthermore, compact portable equipment may contain NOVRAM semiconductor memory circuits and it may be difficult to find this equipment rapidly in an emergency.

- Medium accessibility
  Not an issue, since the "erase" command would be issued either through the normal input keyboard or via some form of "panic" button.

State of Destruct Technology

Proven and existing technology.

Discussion:

NOVRAMs consist of a RAM memory interleaved with an EEPROM. The circuit is usually utilized to serve as a non-volatile memory in the event of a power failure. When the power dips below some pre-determined value, the contents of the RAM memory are rapidly transferred into the EEPROM. One way of clearing the EEPROM is to "clear" the RAM prior to power down.

Destruct Method: ERASING (degaussing)

Storage Medium: Magnetic, Recording, Removable (tape, cartridge, cassette, wafer, card, strip, floppy disk, hard disk)

Effectiveness: High

Process:

The medium is subjected to a strong magnetic field that changes the magnetization representing the stored information.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  The equipment size is variable. It ranges from hand-held permanent magnets to a 5 foot high equipment rack.

- Utility requirements
  Some degaussers require electric power. The power, however, may be supplied by internal batteries.

- Manpower requirements
  Generally, personnel are needed to access, remove, collect and transport the media to the degausser, insert them into the degaussing chamber, and operate the machine.

Safety Concerns

- Accidental trigger
  Possible in units that also serve as storage containers; otherwise, it is not likely since the media has to be inserted into the device and the device activated.

Risk of compromise

- Destruction speed
  Media can be degaussed in less than one minute.

- Throughput
  Throughput can be partitioned into two elements: getting the media to the degaussing equipment and actually degaussing the media. The speed with which the material can be brought and fed to the equipment is site, manpower, and media specific. The actual degaussing throughput is dependent on the volume capacity of the machine, the cycle time, and the number of degaussing units available that can be used in parallel. A typical throughput is one 10 inch reel of 1/2 inch tape per minute.

- Premature termination
  The erase process can be terminated prior to completion by disconnecting system power or removing the media from the degausser. Such media may be partially damaged.

- Destruction completeness
  Medium to excellent. Degaussing may leave some detectable remanent. A higher degree of erasure can be accomplished with multiple passes.

- Information concentration
  Dependent on the specific medium.

- Medium accessibility
  Dependent on the specific medium.

State of Destruct Technology

Proven technology with numerous fielded models.

Discussion:

Modern signal processing techniques enable the recovery of erased information almost irrespective of the erasing method employed. The limiting factor is the amount of processing time necessary to extract the information. Since facilities store billions of bits of information on recording media, erasure to the level that requires on the order of a second of processing time to recover a bit of information renders recovery impractical unless the quantity of material to be processed is very small. If the adversary has access to an index or other directory of the contents of the storage medium, he potentially can identify the exact regions of the medium that contain the information of interest to him, and limit his recovery efforts to that region.

To erase the stored information to a level that makes information recovery impractical, a magnetic field 5 times as strong as the coercivity of the recording medium is necessary. Recording media are degaussed most efficiently if the magnetic field is applied along the easy direction of magnetization. Such a field can be generated by a permanent magnet or by passing a current through coils designed to produce a magnetic field.

In the method that makes use of permanent magnets, the magnet is simply passed very close to the medium surface. The two primary difficulties with permanent magnets are: 1) magnetic field strength decreases very rapidly as the distance from the magnet is increased -- by a factor proportional to the distance from magnet cubed; and 2) permanent magnets of sufficient strength are extremely expensive -- thousands of dollars. Thus, for example, if a magnet is passed along a reel of recording tape, the edges of the tape near the reel flanges would be subjected to a much stronger field than the portion of the tape between the two edges.

Most degaussing equipment utilizes capacitors discharged into multiple coils to generate a strong pulsed magnetic field. The coils may be oriented so as to provide fields in several directions or the medium itself may be mechanically rotated. This ensures that all parts of the medium will be subjected to a magnetic field that is parallel to the easy direction of magnetization.

Perpendicularly recorded media, which are expected to be in use soon, may not be degaussed properly by existing equipment. If inserted into degaussers configured for longitudinal media, perpendicular media would not be subjected to the strongest magnetic field along their easy direction of magnetization.

One final issue that must be taken into consideration when evaluating the effectiveness of destruction by degaussing, is the prior history of the recorded medium. If the medium has been stored at an elevated temperature (temperatures >80°F) for more than a few days, or if the medium has stored the same data for several or more years, then there exists the possibility that the previously recorded signal may be recoverable even after degaussing. Such storage conditions may cause this problem because the binder is like an extremely viscous fluid that has oxide particles suspended in it. During medium manufacture, before the binder has cured, the oxide particles are oriented so they align in one direction. Following recording, the magnetic forces on the oxide particles are such that, but for the binder, the particles would physically re-orient. Normally the viscosity of the binder is sufficient to prevent such re-orientation; but, with extended storage or with storage at elevated temperatures, some re-orientation does occur. This re-orientation can be measured after degaussing.

Destruct Method: ERASING (degaussing)

Storage Medium: Magnetic, Recording, Fixed (hard disk, drum)

Effectiveness: Possibly High

Process:

The medium is subjected to a strong magnetic field that changes the magnetization representing the stored information.

Destruction Issues:

<u>System Overhead Concerns</u>

- Physical Characteristics
  The destruction device is a small, hand-held permanent magnet.

- Manpower requirements
  Generally, personnel are needed to access the media and to manually move the magnet along the medium surface.

<u>Risk of compromise</u>

- Destruction speed
  The magnet need only be brought into close proximity of the medium surface and the information content of the medium area immediately in the vicinity of the magnet is destroyed.

- Throughput
  Throughput can be partitioned into two elements: accessing the media and actually degaussing the media. The speed with which the material can be accessed depends on the specific design of the storage equipment. The actual degaussing throughput is dependent on the surface area to be degaussed and the ease with which all the necessary areas can be reached.

- Premature termination
  The personnel can be prevented from completing their task.

- Destruction completeness
  Medium to excellent. Degaussing may leave some detectable remanent . Careless operator procedures may leave patches of media intact.

- Information concentration
  The storage unit containing the media is connected to, or mounted inside, the information processing equipment.

- Medium accessibility
  Poor. Special tools are required, numerous screws may have to be removed, and seals must be broken.

State of Destruct Technology

Actual effectiveness of technology is unknown.

Discussion:

The two primary difficulties with permanent magnets are: 1) permanent magnets of sufficient strength are extremely expensive -- thousands of dollars; and 2) the field strength decreases very rapidly as the distance from the magnet is increased -- by a factor proportional to the distance from the magnet cubed. Thus, for example, if a magnet is passed too high above the medium surface, the medium may not be degaussed at all.

Destruct Method: ERASING (overwriting)

Storage Medium: Magnetic, Recording, All Types

Effectiveness: High

Process:

The medium is subjected to a strong magnetic field that changes the magnetization representing the stored information.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  The equipment necessary to erase magnetic media by overwriting is usually a feature of the information processing equipment utilizing the media.

- Utility requirements
  Electric power to operate the information processing equipment.

- Manpower requirements
  Personnel are needed to identify, locate and transport the media to the drive unit, mount the media onto the drive, and initiate the erase process.

Risk of compromise

- Destruction ,peed
  Depends on media type and storage capacity.

- Throughput
  Throughput is limited by the personnel's ability to get the media to the drive unit and the equipment's speed at overwriting the media.

- Premature termination
  The erase process can be terminated prior to completion by disconnecting information processing system power or issuing a command sequence terminating the overwrite process.

- Destruction completeness
  Medium to excellent. Overwriting may leave some detectable remanent . Multiple passes overwriting alternating ones and zeros reduces the amount of remnant that can be discerned.

- Information concentration
  Dependent on the specific medium.

- Medium accessibility
  Dependent on the specific medium.

State of Destruct Technology

Proven technology existing on all information processing equipment.

Discussion:

Modern signal processing techniques enable the recovery of erased information almost irrespective of the erasing method employed. The limiting factor is the amount of processing time necessary to extract the information. Since facilities store billions of bits of information on recording media, erasure to the level that requires on the order of a second of processing time to recover a bit of information renders recovery impractical unless the quantity of material to be processed is very small. If the adversary has access to an index or other directory of the contents of the storage medium, he potentially can identify the exact regions of the medium that contain the information of interest to him, and limit his recovery efforts to that region.

To erase the stored information to a level that makes information recovery impractical, it is necessary to apply a magnetic field 5 times as strong as the coercivity of the recording medium. A magnetic recording head generates magnetic field that is about 750 to 1500 Oe. Low coercivity media (i. e. 260 Oe), can be readily overwritten with this strength field. High coercivity media (i. e. 700 Oe) retain a significant remnant. Although this remnant does not interfere with information subsequently recorded on the media, it can be discerned with signal processing techniques.

Most information processing equipment provides a command to delete the complete medium or only specified files, but the process involved does not truly erase the information. Rather, only the references to the appropriate files in the medium directory are deleted, allowing that storage space to be overwritten at some later time. Such processes should not be relied upon for emergency destruction since the information is readily recoverable with simple software tools.

Destruct Method: ERASING

Storage Medium: Magnetic, Current-Accessed, Core

Effectiveness: High

Process:

Each memory location is addressed and overwritten with some random value.

Destruction Issues:

<u>System Overhead Concerns</u>

- Physical Characteristics
  Usually exists as a feature of the information processing equipment.

- Utility requirements
  The information processing equipment must be operable.

<u>Safety Concerns</u>

- Accidental trigger
  The memory contents can be unintentionally erased if the "erase" command is accidentally entered.

<u>Risk of compromise</u>

- Destruction speed
  Depends on the clocking speed of the information processing equipment. The destruct speed also depends on the degree of erasure required, since the contents should be overwritten multiple times to truly remove all remnants of the previously stored information.

- Throughput
  It should be possible to overwrite the entire memory contents a sufficient number times in the span of a few minutes to preclude recovery of the previously stored information.

- Premature termination
  Possible to terminate by either overriding the "erase" command or by removing power to the information processing equipment.

- Destruction completeness
  Medium to excellent. The absolute degree of memory erasure depends on the number of overwrite cycles accomplished.

- Information concentration
  The information is located within the memory planes, which are integral to the information processing equipment. As such, equipment containing core memory modules can be distributed throughout a facility. Furthermore, portable equipment may contain core memory modules and it may be difficult to rapidly find this equipment in an emergency.

- Medium accessibility
  Not an issue since the memory elements are accessed electronically through the the information processing system control structure.

State of Destruct Technology

Overwrite technology is an existing capability of most information processing equipment.

Discussion:

The DoD-approved method for declassifying magnetic core memory calls for overwriting all addressable data locations by writing any one character, then its complement alternately for 1000 cycles, followed by overwriting with unclassified random data. Department of Defense Magnetic Remanence Security Guideline, National Computer Security Center, 15 November, 1985, at 15.

Destruct Method: ERASING

Storage Medium: Magnetic, Current-Accessed, Plated Wire

Effectiveness: Poor to Medium

Process:

Each memory location is addressed and overwritten with some random value.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Usually exists as a feature of the information processing equipment.

- Utility requirements
  The information processing equipment must be operable.

Safety Concerns

- Accidental trigger
  The memory contents can be unintentionally erased if the "erase" command is accidentally entered.

Risk of compromise

- Destruction speed
  Depends on the clocking speed of the information processing equipment. The destruct speed also depends on the degree of erasure required, since the contents should be written over multiple times to truly remove all remanents of the previously stored information.

- Throughput
  It should be possible to overwrite the entire memory contents a sufficient number times in the span of a few minutes to preclude recovery of the previously stored information.

- Premature termination
  Possible to terminate by either overriding the "erase" command or by removing power to the information processing equipment.

- Destruction completeness
  Poor to medium. If the information has been stored in a plated wire memory for a long time (exceeding 72 hours), it is virtually impossible to overwrite the memory contents in a manner that precludes the recovery of the previously stored information.

- Information concentration
  The information is located within the memory planes, which are integral to the information processing equipment. As such, equipment containing plated wire memory modules can be distributed throughout a facility.

- **Medium accessibility**
  Not an issue since the memory elements are accessed electronically through the the information processing system control structure.

State of Destruct Technology

Overwrite technology is an existing capability of most information processing equipment.

Discussion:

The DoD-approved method for declassifying plated wire memory calls for overwriting all addressable data locations by writing any one character, then its complement alternately for 1000 cycles, followed by overwriting with unclassified random data. This procedure is effective only if the prior information had been stored for less than 72 hours. Even if the classified information has been stored for less than 72 hours, the random unclassified data must be stored for at least 72 hours at a temperature matching or exceeding the temperature present during the storage of the classified data. Department of Defense Magnetic Remanence Security Guideline, National Computer Security Center, 15 November, 1985, at 16.

Destruct Method: ERASING

Storage Medium: Magnetic, Bubble

Effectiveness: High

Process:

A current pulse is applied to a coil in the bubble memory module that sharply raises the perpendicular bias field, causing the bubble domains to collapse.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Usually exists as a feature of the information processing equipment.

- Utility requirements
  Although a current pulse is required, it can be provided by a capacitor discharge or batteries.

Safety Concerns

- Accidental trigger
  The memory contents can be accidentally erased if the current pulse is accidentally triggered.

Risk of compromise

- Destruction speed
  The entire contents of a bubble memory can be completely erased in microseconds.

- Throughput
  Depends only on the number of discrete trigger "buttons" at a facility and how rapidly personnel can get to them.

- Premature termination
  Not possible once initiated. The destruct mechanism can be disabled if the wire connections from the trigger point to the memory module are severed prior to trigger.

- Destruction completeness
  Excellent. The memory contents are completely erased with no remnants.

- Information concentration
  The information is located within the memory modules, which are integral to the information processing equipment. As such, equipment containing bubble memory modules can be distributed throughout a facility. Furthermore, compact portable equipment may contain bubble memory modules and it may be difficult to rapidly find this equipment in an emergency.

- Medium accessibility
  Not an issue, provided the equipment is pre-wired so that the perpendicular bias

fields of the bubble memory modules can be triggered without having to access the modules themselves.

State of Destruct Technology

Proven technology and existing feature of every memory module.

Discussion:

Magnetic bubble memories are extremely well suited for rapid erasure in an emergency.

Destruct Method: ERASING

Storage Medium: Optical, Microform

Effectiveness: Not applicable/practical

Discussion:

There is no way to erase or reverse the image that has been stored on microform media.

Destruct Method: ERASING

Storage Medium: Optical Storage, Laser-Accessed

Effectiveness: Not applicable or practical

Discussion:

Even though some laser-accessed storage media are being designed to permit users to store or remove information from the storage medium, this process is not practical for emergency situations. Optical storage media can store in the range of 1 to 4 Gbytes of data. Assuming that the associated drive equipment could write at the rate of 1 million bits per second, overwriting the entire medium would require from 2 to 8 hours. There have been no reports of methods for bulk erasing laser-accessed optical media. Similarly, no reports on remnants following overwriting were found.

Destruct Method: ERASING

Storage Medium: Punched, All Types

Effectiveness: Not applicable/practical

Discussion:

In punched media, information is represented and stored by the pattern of punched holes. The holes are punched in precise locations following standard encoding schemes. Once the holes are punched, there is no way to replace the material that has been removed and to return the medium to its initial, unused condition. The medium can be overwritten by punching out all the possible hole locations, thereby obliterating the stored information. This process, however, is very slow and, therefore, not practical.

Destruct Method: ERASING

Storage Medium: Paper, All Types

Effectiveness: Not applicable/practical

Discussion:

The cost of paper is too low to warrant erasing for reuse. As such, there is no existing technology base to apply in emergency conditions. Even if such technology did exist, it is unlikely that the process would be rapid or thorough enough to be truly useful.

SECTION G

HEAT AND INCINERATION

Generic Description of HEAT AND INCINERATION

Destruction Issues:

System Overhead Concerns

- Physical characteristics
  Destruction by heat or incineration requires some mechanism for raising the temperature of the medium. For safety reasons, the heat must be generated and contained within an appropriate container. The size of such a container depends on the specific implementation and can vary from less than a cubic foot to many cubic feet in volume.

- Utility requirements
  A source of heat, adequate ventilation, and a method for isolating the heat from other flammable materials in the proximity are all necessary.

- Manpower requirements
  Personnel may be needed for any or all of the following: to transport the media to the incineration point, to time the throughput, or to trigger the destruct mechanism.

Safety Concerns

- Process
  Unless they are properly contained and vented, smoke, toxic or irritating fumes, heat, flames, and sparks generated by combustion can injure personnel. The heat, flames and sparks can cause fire to spread and may result in damage to surrounding structural elements.

- Materials
  The pyrotechnic materials used to generate heat rapidly and support the incineration process can be hazardous to store and handle. Specific hazards depend on the type and quantity of the incendiary material.

- Accidental trigger
  Media storage units that contain the incendiary materials and serve as the destruct container are more prone to accidental trigger. On the other hand, incendiary units that require material to be transported to and fed into the unit are much less subject to accidental destruction.

- Emergency environment
  Open flames and smoke increase the inherent dangers of the emergency environment. Smoke obscures visibility while the flames and heat can caure the spread of fire.

Risk of compromise

- Destruction speed
  The extent of damage inflicted on the medium depends on the temperature that the medium attains. As such, the destruction speed depends on how fast the heat source can raise all parts of the medium to a certain temperature. If the medium is wound on

reels, or otherwise compacted, the portions of the medium that are far away from the heat source may take a significantly longer amount of time to destroy.

- Throughput
  Dependent on the specific implementation. Implementations in which a set amount of chemical oxidizer is mounted into some container are usually limited to destroying the material that was in the container at the initiation of the burn. A "burn" usually lasts about 1/2 hour. The throughput of incinerators that permit the constant addition of both fuel and media depends on factors such as the size of the incinerator, the form of the media (compacted or loose), and the personnels' ability to identify, collect, and transport the media to the incinerator.

- Premature termination
  Unless the incineration is carried out in a sealed container, partially destroyed media can be pulled out, or the fire can be extinguished before sufficient damage is inflicted. The fire can be extinguished by cutting off the oxygen supply (unless some internal means of generating oxygen is provided) or dousing the burning material with extinguishing material.

- Destruction completeness
  Depends on the specific medium-incineration system combination. If all parts of the medium are not sufficiently heated, information may still be recovered.

- Detectability
  Unless they are removed by some form of "scrubber", the smoke and fumes generated by combustion make this method readily detectable from the outside.

- Information concentration
  Depends on specific medium-facility factors. Information frequently will be concentrated in file cabinets or bookcases. Since information is rarely cataloged and stored by sensitivity category, a major task may be the identification and separation of highly sensitive information from less sensitive material.

- Medium accessibility
  Depends on specific medium-facility-equipment factors. The difficulty and complexity of accessing media is set, in part, by the specific medium and whether it was designed to be fixed or removable. The removal of fixed media may be relatively complex and may require special tools and training. Both fixed and removable media may be stored in secure containers or housings, which in turn may delay accessing the actual media. In situations where a chemical dispensing mechanism is built integral to the equipment, accessibility is not a major factor.

State of Destruct Technology

A number of incineration destruct devices have been designed and implemented.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Semiconductor, All Types

Effectiveness: Medium to High

Process:

The temperature of the semiconductor memory element is raised to a level at which the electronic properties of the device are altered sufficiently to preclude the recovery of any stored information.

Destruction Issues:

Safety Concerns

- Materials
  The plastic packaging materials and other components on the circuit cards may emit toxic or irritating fumes when heated.

Risk of compromise

- Throughput
  If the circuit cards containing the semiconductor memory devices must be removed from the equipment and transported to some common incineration point, then throughput will be determined to a large extent on the personnel's ability to perform this activity. If the pyrotechnics are mounted integral to the information processing equipment, then the throughput will be determined by how fast the personnel can trigger the individual units.

- Destruction completeness
  If the temperature of a semiconductor device is not raised sufficiently to alter the electronic characteristics, then it may be possible to extract previously stored information.

- Medium accessibility
  Semiconductor memories are not usually user-accessible.

State of Destruct Technology

No systems utilizing incineration for the destruction of information stored in semiconductor memories have been identified.

Discussion:

The most commonly used semiconductor material, silicon, melts at 1410°C. Even before this temperature is reached, the information content of the device can be effectively destroyed. The metalization layer is usually aluminum which melts at 660°C (1220°F). At temperatures below the melting point, complex processes take place within the semiconductor material and the various dielectric materials that comprise the semiconductor memory device. The effects of high temperatures include changes in material conductivity/resistivity. Since many non-volatile semiconductor memories store information in the form of trapped electrical charge, a change in the resistivity of an insulator may cause the charge to dissipate, destroying the information content. Furthermore, since the more exotic information reconstruction techniques that can be used to read information that had been stored on volatile memories rely on measuring very small changes in device operating parameters, exposing a memory to higher temperatures (several hundred degrees Centigrade) may alter device operating characteristics sufficiently to preclude accurate measurement of the parameters necessary to reconstruct previously stored information. Further research is necessary to establish how hot a semiconductor device must get before the information that had been stored on it is no longer retrievable.

Circuit boards that contain a layer of pyrotechnic material have been proposed and fabricated. Upon trigger, the board ignites and components mounted on such a circuit board are severely damaged. It is unknown whether the damage inflicted on semiconductor memories is sufficient to preclude information recovery.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Magnetic, Recording, Mylar Substrate (Reel-To-Reel, Cassette, Cartridge, Floppy Disk, Card)

Effectiveness: High

Process:

The temperature of the medium is raised to either above the Curie point, or to a level at which the Mylar base disintegrates.

Destruction Issues:

Safety Concerns

- Materials
  The pyrotechnic materials necessary to support combustion or that generate sufficient heat may be hazardous. Aluminum reels in conjunction with the ferric oxide on the media may present an explosion hazard if they are incinerated with sodium nitrate.

Risk of compromise

- Throughput
  Throughput is affected by the degree of media compaction - tape media wound on a reels burns slower than loose media.

- Destruction completeness
  If all the media are not raised to above the Curie point, or if the substrate is not sufficiently damaged, the information will still be extractable. If the medium is tape is wound on a reel, the tracks away from the outside edges do not heat as fast and may be incompletely destroyed.

- Detectability
  Incineration may be detectable from the outside due to generated smoke which must be vented. Where applicable, heating to a low temperature Curie point may not be associated with any externally observable signs.

- Information concentration
  Tape media will frequently be found in central "libraries"; other magnetic recording media may be widely distributed throughout a facility.

- Medium accessibility
  Mylar-based media are usually readily accessible.

State of Destruct Technology

No systems that have been specifically designed for destroying magnetic media with heat have been identified. Incinerating containers that have been designed primarily for paper can readily destroy magnetic media. Such units should be used with caution since sodium nitrate (a common oxidizer), ferric oxide (a magnetic medium), and aluminum (frequently used for tape reels or cartridge components) react violently when heated and explode. Since the chromium dioxide medium has increased in popularity and is rapidly becoming the new "standard" as a 1/2 inch cartridge medium, research into systems that destroy the contents by elevating the temperature represents a potential high pay-off research area.

Discussion:

The Curie points of popular magnetic recording media vary widely. For example, the Curie point of chromium dioxide is only about 135°C (275°F), while that of gamma ferric oxide is 675°C (1247°F). The Mylar substrate is destroyed well before the ferric oxide Curie temperature is reached.

Elevated temperatures have a profound effect on Mylar:

121°C	(250°F)	Mylar distorts;
160°C	(320°F)	Mylar and binder become soft, layer-to-layer adhesion in wound tapes begins;
288°C	(350°F)	Mylar and binder darken and become brittle;
538°C	(1000°F)	Mylar and binder char.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Magnetic, Recording, Hard Disk, Removable (Metal Substrate)

Effectiveness: High

Process:

The temperature of the medium is raised to either above the Curie point, or to a level at which the metal substrate melts.

Destruction Issues:

Safety Concerns

- Materials
  The aluminum substrates, in conjunction with the ferric oxide on some media, may present an explosion hazard if they are incinerated with sodium nitrate.

Risk of compromise

- Destruction speed
  The speed with which removable hard disks can be destroyed depends on how fast the medium can be collected and transported to the incineration point. Once the medium is in the incineration unit, the speed with which the medium is destroyed depends on how fast its temperature can be raised to the necessary level.

- Destruction completeness
  If the media are not raised to above the Curie point, or if the substrate is not sufficiently damaged, the information will still be extractable.

- Detectability
  Incineration may be detectable from the outside due to generated smoke which must be vented. Where applicable, heating to a low temperature Curie point may not be associated with any externally observable signs.

- Information concentration
  Removable hard disk media are usually found in close proximity to the device that they are used with or in media libraries.

- Medium accessibility
  Unless they are locked in secure containers, removable hard disk media are usually readily accessible.

State of Destruct Technology

No systems that have been specifically designed for destroying removable hard disk media with heat have been identified. Incinerating containers that have been designed primarily for paper can readily destroy magnetic media. Such units should be used with caution since sodium nitrate (a common oxidizer), ferric oxide (a magnetic medium), and aluminum (frequently used for tape reels or cartridge components) react violently when heated and explode.

Discussion:

The Curie points of popular magnetic recording media vary widely. For example, the Curie point of chromium dioxide is only about 135°C (275°F), while that of gamma ferric oxide is 675°C (1247°F).

The melting point of aluminum, the most common substrate material is about 660°C (1220°F); the exact temperature depends on the specific alloy used.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Magnetic, Recording, Hard Disk, Fixed (Metal Substrate)

Effectiveness: Medium (low Curie point media) to Poor (high Curie point media)

Process:

The temperature of the medium is raised to either above the Curie point, or to a level at which the metal substrate melts.

Destruction Issues:

Safety Concerns

- Materials
  Aluminum substrates, in conjunction with the ferric oxide used on some media, may present an explosion hazard if sodium nitrate is the oxidizing material.

- Accidental trigger
  Since the heat generating materials or mechanism need to be mounted integral to the disk drive unit, there exists a possibility of accidental trigger.

Risk of compromise

- Throughput
  Since each destruct mechanism is integral to the disk drive unit, the throughput will be determined by how fast the personnel can trigger the individual units.

- Destruction completeness
  If the media are not raised to above the Curie point, or if the substrate is not sufficiently damaged, the information will still be extractable.

- Detectability
  Where applicable, heating to a low temperature Curie point may not be associated with any externally observable signs.

- Medium accessibility
  Fixed hard disk media are not user-accessible.

State of Destruct Technology

We have not found any manufacturer making fixed hard disk storage systems with an integral, heat generating destruct capability. Secure Data Corporation of Scottsdale, AZ, however, has developed a method for integrating several Winchester-type hard disk units into a GSA-approved, Mosler Class 6 security filing cabinet. Since Unidynamics of Phoenix, AZ makes incinerating containers based on a Mosler cabinet, it may be possible to combine the technology of these two units to create an incinerating safe for certain types of fixed hard disk media.

Discussion:

The Curie points of popular magnetic recording media vary widely. For example, the Curie point of chromium dioxide is only about 135°C (275°F), while that of gamma ferric oxide is 675°C (1247°F). It should be relatively simple to design a disk drive that uses low Curie point media with an electric heating element that could raise the internal temperature of the disk drive unit to above the Curie point. If the recording medium were to have a Curie point at 275°F (chromium dioxide), such an oven-like unit could be relatively safe and simple.

The melting point of aluminum, the most common hard disk substrate material is about 660°C (1220°F); the exact melting temperature depends on the specific alloy used.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Magnetic, Recording, Drum

Effectiveness: Not applicable/practical

Discussion:

Magnetic drums are hermetically sealed units that are usually integral to the information processing equipment. This technology is obsolete and only remains in older, fielded equipment. Since drums are no longer used in new equipment, a research effort on how to destroy drums with heat and incineration is not warranted. Retro-fitting existing equipment to include an internal destruct mechanism would virtually require a custom designed destruct system for each drum unit. Accessing and removing a drum in order to place it into some incinerating device is time consuming and not practical under emergency conditions.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Magnetic, Current-Accessed (Core, Twistor, Plated Wire)

Effectiveness: Possibly high

Process:

The temperature of the medium is raised to either above the Curie point of the ferrite cores, or to a level at which the wire address lines melt..

Destruction Issues:

Safety Concerns

- Accidental trigger
  Since the heat generating materials or mechanism need to be mounted integral to the memory unit, there exists a possibility of accidental trigger.

Risk of compromise

- Throughput
  Since each destruct mechanism is integral to the memory unit, the throughput will be determined by how fast the personnel can trigger the individual units.

- Destruction completeness
  If the storage media components are not raised to above their Curie point, or if the address lines are not molten and the storage elements physically randomized, the information could possibly still be extractable.

- Medium accessibility
  Memories are usually housed within the processing equipment chassis and are not user-accessible.

State of Destruct Technology

No heat destruct mechanisms designed specifically for current addressed memories have been identified. Incineration equipment designed for destroying paper media could be used for destroying current addressed memories but the memory planes would first have to be physically removed from the equipment.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Magnetic, Bubble

Effectiveness: Unknown

Discussion:

Bubble memories are packaged as an integral, hermetically sealed unit containing permanent magnets for the bias field, the bubble material die, and drive coils for the rotating in-plane field. The effect of heat on the bubble material die storing the information needs further research. It can be conjectured that as the temperature of the module rises, the magnetic field strength of the permanent magnets will decrease, and at some point the field will be insufficient to support the magnetic domains.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Optical, Microform

Effectiveness: High

Process:

The temperature of the medium is raised to a level at which the microform film base melts or burns.

Destruction Issues:

Safety Concerns

- Process
  Fumes evolved by the plastic microform film base during combustion may be toxic or irritating.

Risk of compromise

- Destruction speed
  If the film is wound on reels, or if large quantities of stacked microfiche media are to be destroyed at once, some portions of the media may be far away from the heat source and therefore, may take a significantly longer amount of time to destroy.

- Destruction completeness
  If all the media are not raised to a point where the film base transforms into ash (or a molten mass), information may still be extractable.

- Information concentration
  Microforms are small and highly portable. Microfilm on reels tends to be housed in protective boxes and stored in special file cabinets. Microfiche are housed in protective paper sleeves and are likewise frequently stored in cabinets. Because they are flat and readily available in "user copies," microfiche tend to be distributed throughout a facility: in desk drawers, in files, etc.

- Medium accessibility
  Microform media are usually readily accessible unless stored in secure containers.

State of Destruct Technology

Incinerating containers that have been designed primarily for paper can readily destroy microform media. Security Engineered Machinery Corporation used to manufacture a small, electric desktop unit that destroyed microforms by melting them. The unit could handle several sheets at a time and took about 30 minutes to cycle. This product has been discontinued.

Discussion:

Old film base used to be nitrocellulose which burned very vigorously. Because of this flammability, nitrocellulose is no longer used. Present day film bases do not ignite easily, but once lit, they will burn, dripping flaming molten plastic material.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Optical, Laser-Accessed

Effectiveness: Unknown

Discussion:

Laser-accessed information storage is a new and rapidly evolving technology. As such, no dominant product types have yet evolved. Media configurations are still highly proprietary and experimental. Without specific details as to media construction and materials (e.g., metal plastic, glass), it is difficult to predict if and how heat would affect the information content. Since information storage is accomplished by heating a localized area of the disk surface to change its characteristics, thereby representing information, it can be conjectured that heat would be effective at destroying the information content of laser accessed optical storage media. Further research is necessary to determine how much heat is necessary and what is the best method of applying this heat.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Punched, Paper-Based (Cards, Tape)

Effectiveness: High

Process:

The temperature of the paper-based punched medium is raised until it ignites and burns.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics

  Paper-based punched media are burned in some form of open or sealed container. The size of the container can be highly variable. A common container form factor is the security file cabinet.

- Utility requirements

  Combustion requires a source of oxygen and some conduit for venting the generated smoke and fumes. About 0.83 pounds of oxygen are required to burn one pound of paper-based media. The container must be insulated from its surroundings to prevent scorching or fire.

- Manpower requirements

  Personnel are required to collect the media, transport them to the destruct equipment, and to feed them into the device. Destruct devices that also serve as medium storage containers require less manpower to implement destruction.

Risk of compromise

- Destruction speed

  Depends on the quantity of paper-based punched media, and the properties of the incendiary material. In general, however, since punched cards consist of 99 pound stock, and tend to be stored in tight stacks, the speed of destruction of punched cards will be significantly slower than that of a comparable volume of paper. Similarly, punched tapes that are wound on reels will take longer to destroy than loose tapes. The oil content of some paper tapes may enhance the combustion process.

- Destruction completeness

  If combustion proceeds to completion, the medium is usually completely destroyed. Paper, however, is a relatively good insulator, and if stacks of punched cards, or reels of punched tape are burned without stoking, large sections of the interior material may remain undamaged. If combustion is carried out outdoors in uncovered containers, updrafts can actually cause paper to fly out of the container and disperse over the surrounding area.

- Information concentration

  Punched cards tend to be stored in file cabinets designed for their size, cardboard boxes holding up to 2,000 cards, or in stacks simply bound with elastic bands. Although cards can be located virtually anywhere in a facility, they tend to be in discreet clusters. Punched tapes tend to be stored on reels up to 14 inches in diameter, as coils, or fanfolded in containers.

- Medium accessibility
  Readily accessible unless stored in secure containers. The major difficulty is not getting to the material, but rather separating the sensitive material from the sheer volume of other material.

State of Destruct Technology

A number or different versions of incendiary units have been developed, tested and implemented.

Discussion:

Secure containers with internal combustion mechanisms represent a potentially high payoff research area.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Punched, Mylar-Based

Effectiveness: High

Process:

The temperature of the medium is raised to a level at which the Mylar disintegrates.

Destruction Issues:

Risk of compromise

- Destruction speed
  The extent of damage inflicted on the medium depends on the temperature that the Mylar attains. As such, the destruction speed depends on how fast the heat source can raise all parts of the punched mylar tape medium to a certain temperature.

- Destruction completeness
  If all the media are not raised to a point where the mylar transforms into ash, information may still be extractable.

- Information concentration
  Punched tapes tend to be stored on reels up to 14 inches in diameter, as coils, or fan-folded in containers.

- Medium accessibility
  Mylar-based punched tape media are usually readily accessible.

State of Destruct Technology

Incinerating containers that have been designed primarily for paper can readily destroy Mylar-based punched tape media.

Discussion:

Elevated temperatures have a profound effect on Mylar:

121°C	(250°F)	Mylar distorts;
160°C	(320°F)	Mylar becomes soft, layer-to-layer adhesion in wound tapes begins;
288°C	(350°F)	Mylar darkens and becomes brittle;
538°C	(1000°F)	Mylar chars.

Destruct Method: HEAT AND INCINERATION

Storage Medium: Paper, All Types

Effectiveness: High

Process:

The temperature of the paper medium is raised until it ignites and burns.

Destruction Issues:

System Overhead Concerns

- Physical Characteristics
  Paper is burned in some form of open or sealed container. The size of the container can be highly variable. A common container form factor is the security file cabinet.

- Utility requirements
  Combustion requires a source of oxygen and some conduit for venting the generated smoke and fumes. About 0.83 pounds of oxygen are required to burn one pound of paper. The container must be insulated from its surroundings to prevent scorching or fire.

- Manpower requirements
  Personnel are required to collect the media, transport them to the destruct equipment, and feed them into the device. Destruct devices that also serve as medium storage containers require less manpower to implement destruction.

Risk of compromise

- Destruction speed
  Depends on the quantity of paper, its weight, degree of compaction, and the properties of the incendiary material.

- Destruction completeness
  If combustion proceeds to completion, the medium is usually completely destroyed. Paper, however, is a relatively good insulator, and when items, such as bound volumes or thick stacks of paper, are burned without stoking, large sections of the interior material may remain undamaged. If combustion is carried out outdoors in uncovered containers, updrafts can actually cause paper to fly out of the container and disperse over the surrounding area.

- Information concentration
  Paper tends to be randomly distributed everywhere throughout a facility. Some degree of information concentration exists in the form of file cabinets.

- Medium accessibility
  Readily accessible unless stored in secure containers. The major difficulty is not getting to the material, rather separating the sensitive material from the sheer volume of other material.

State of Destruct Technology

A number or different versions of incendiary units have been developed, tested and implemented.

Discussion:

Secure containers with internal combustion mechanisms represent a potentially high payoff research area.

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