

SECTION 3—CHEMICAL AND BIOLOGICAL SYSTEMS TECHNOLOGY

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OVERVIEW

This section addresses technologies for: Bioprocessing; Chemical Manufacturing; Chemical and Biological Defense Systems; Detection, Warning and Identification; Battlefield Environment; and Human Factors. The technology areas identified in the above box contain militarily critical technologies. The other technology areas do not currently include technologies that are militarily critical. The **Chemical and Biological Defense Systems** section includes technologies that are designed to protect forces when contamination cannot be avoided and provide prophylaxis and therapy from threat agents to any affected forces. These Chemical and Biological Defense Systems technologies also cover decontamination to ensure rapid force reconstitution. **Detection, Warning and Identification** technologies covered in this section can provide real-time capability to detect, identify, locate, and quantify chemical and biological threats. Sensors must be integrated with an information processing system to analyze the threat, identify potentially affected units, and pass on alarms and warnings to implement protective measures. Both detection and protection apply to personnel operating on the ground, at sea, in the air, and in shelters and large enclosures. Although many sensor and defense technologies have commercial applications, military requirements are much more stringent. Selected toxic chemicals and biological agents which are of concern for defense and detection are presented in tabular form (see Figs. 3.0-1 and 3.0-2). Toxic chemicals are extracted from the Chemical Weapons Convention. Biological agents are extracted from the Australia Group list.

<p style="text-align: center;">Viruses</p> <p>V1. Chikungunya virus V2. Congo-Crimean haemorrhagic fever virus V3. Dengue fever virus V4. Eastern equine encephalitis virus V5. Ebola virus V6. Hantaan virus V7. Junin virus V8. Lassa fever virus V9. Lymphocytic choriomeningitis virus V10. Machupo virus V11. Marburg virus V12. Monkey pox virus V13. Rift Valley fever virus V14. Tick-borne encephalitis virus (Russian Spring-Summer encephalitis virus) V15. Variola virus V16. Venezuelan equine encephalitis virus V17. Western equine encephalitis virus V18. White pox V19. Yellow fever virus V20. Japanese encephalitis virus</p>	<p style="text-align: center;">Bacteria</p> <p>B1. Bacillus anthracis B2. Brucella abortus B3. Brucella melitensis B4. Brucella suis B5. Chlamydia psittaci B6. Clostridium botulinum B7. Francisella tularensis B8. Burkholderia mallei (pseudomonas mallei) B9. Burkholderia pseudomallei B10. Salmonella typhi B11. Shigella dysenteriae B12. Vibrio cholerae B13. Yersinia pestis</p>	<p style="text-align: center;">Toxins</p> <p>T1. Botulinum toxins T2. Clostridium perfringens toxins T3. Conotoxin T4. Ricin T5. Saxitoxin T6. Shiga toxin T7. Staphylococcus aureus toxins T8. Tetrodotoxin T9. Verotoxin T10. Microcystin (Cyanoginosis)</p>
<p style="text-align: center;">Rickettsiae</p> <p>R1. Coxiella burnetii R2. Bartonella Quintana (Rochlimea quintana, Rickettsia quintana) R3. Rickettsia prowasecki R4. Rickettsia rickettsii</p>	<p style="text-align: center;">Genetically Modified Micro-organisms</p> <p>G1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity and are derived from organisms in the core list. G2. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences coding for any of the toxins in the core list, or their subunits.</p>	<p style="text-align: center;">Viruses (Warning Light)</p> <p>WV1. Kyasanur Forest virus WV2. Louping ill virus WV3. Murray Valley encephalitis virus WV4. Omsk haemorrhagic fever virus WV5. Oropouche virus WV6. Powassan virus WV7. Rocio virus WV8. St Louis encephalitis virus</p>
		<p style="text-align: center;">Bacteria (Warning Light)</p> <p>WB1. Clostridium perfringens WB2. Clostridium tetani WB3. Enterohaemorrhagic Escherichia coli, serotype 0157 and other verotoxin producing serotypes WB4. Legionella pneumophila WB5. Yersinia pseudotuberculosis</p>

(Continued)

Figure 3.0-1. Australia Group Biological/Toxin Warfare Agents

<p>Genetically Modified Micro-organisms</p> <p>G1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity and are derived from organisms in the warning list.</p> <p>G2. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences coding for any of the toxins in the warning list, or their subunits.</p>	<p>Animal Pathogens (cont'd)</p> <p>Viruses: AV8. Lyssa virus AV9. Newcastle disease virus AV10. Peste des petits ruminants virus AV11. Porcine enterovirus type 9 (synonym: swine vesicular disease virus) AV12. Rinderpest virus AV13. Sheep pox virus AV14. Teschen disease virus AV15. Vesicular stomatitis</p> <p>Bacteria: AB3. Mycoplasma mycoides</p> <p>Genetically Modified Micro-organisms AG1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity and are derived from organisms in the list.</p>	<p>Plant Pathogens (cont'd)</p> <p>PF5. Puccinia striiformis (syn. Puccinia glumarum) PF6. Pyricularia grisea/Pyricularia oryzae</p> <p>Genetically Modified Micro-organisms PG1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity derived from the plant pathogens on the list.</p>
<p>Toxins (Warning Light)</p> <p>WT1. Abrin WT2. Cholera toxin WT3. Tetanus toxin WT4. Trichothecene mycotoxins WT5. Modecin WT6. Volkensin WT7. Viscum Album Lectin 1 (Viscumin)</p>	<p>Plant Pathogens</p> <p>Bacteria: PB1. Xanthomonas albilineans PB2. Xanthomonas campestris pv. citri</p> <p>Fungi: PF1. Colletotrichum coffeanum var. virulans (Colletotrichum Kanawae) PF2. Cochliobolus miyabeanus (Helminthosporium oryzae) PF3. Microcyclus ulei (syn. Dothidella ulei) PF4. Puccinia graminis (syn. Puccinia graminis f. sp. tritici)</p> <p style="text-align: right;">(cont'd)</p>	<p>Awareness Raising Guidelines</p> <p>Bacteria: PWB1. Xanthomonas campestris pv. oryzae PWB2. Xylella fastidiosa</p> <p>Fungi: PWF1. Deuterophoma tracheiphila (syn. Phoma tracheiphila) PWF2. Monilia rorei (syn. Moniliophthora rorei)</p> <p>Viruses: PWW1. Banana bunchy top virus</p> <p>Genetically Modified Micro-organisms PWG1. Genetically modified micro-organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity derived from the plant pathogens identified on the awareness raising list.</p>
<p>Animal Pathogens</p> <p>Viruses: AV1. African swine fever virus AV2. Avian influenza virus AV3. Bluetongue virus AV4. Foot and mouth disease virus AV5. Goat pox virus AV6. Herpes virus (Aujeszky's disease) AV7. Hog cholera virus (synonym: Swine fever virus)</p> <p style="text-align: right;">(cont'd)</p>		

Figure 3.0-1. Australia Group Biological/Toxin Warfare Agents (Continued)

<p>Nerve Agents (C.A.S. Number)**</p> <p>O-Alkyl ($\leq C_{10}$, incl. cycloalkyl) alkyl (Me, Et, n-Pr or i-Pr)-phosphonofluoridates (107-44-8) e.g. Sarin: O-Isopropyl methylphosphonofluoridate (96-64-0) Soman: O-Pinacolyl methylphosphonofluoridate</p> <p>O-Alkyl ($\leq C_{10}$, incl. cycloalkyl) N,N-dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidocyanidates e.g. Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate (77-81-6)</p> <p>O-Alkyl (H or $\leq C_{10}$, incl. cycloalkyl) S-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonothiolates and corresponding alkylated or protonated salts e.g. VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate (50782-69-9)</p> <p>Vesicants Sulfur mustards: 2-Chloroethylchloromethylsulfide (2625-76-5) Mustard gas: Bis(2-chloroethyl)sulfide (505-60-2) Bis(2-chloroethylthio)methane (63869-13-6) Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane (3563-36-8) 1,3-Bis(2-chloroethylthio)-n-propane (63905-10-2) 1,4-Bis(2-chloroethylthio)-n-butane (142868-93-7) 1,5-Bis(2-chloroethylthio)-n-pentane (142868-94-8) Bis(2-chloroethylthiomethyl)ether (63918-90-1) O-Mustard: Bis(2-chloroethylthioethyl)ether (63918-89-8)</p>	<p>Vesicants (cont'd)</p> <p>Lewisites: Lewisite 1: 2-Chlorovinylchloroarsine (541-25-3) Lewisite 2: Bis(2-chlorovinyl)chloroarsine (40334-69-8) Lewisite 3: Tris(2-chlorovinyl)arsine (40334-70-1)</p> <p>Nitrogen mustards: Lewisite 1: 2-Chlorovinylchloroarsine (538-07-8) Lewisite 2: Bis(2-chlorovinyl)chloroarsine (51-75-2) Lewisite 3: Tris(2-chlorovinyl)arsine (555-77-1)</p> <p>Toxins Saxitoxin (35523-89-8) Ricin (0990-86-3)</p> <p>Choking Agent Phosgene: Carbonyl dichloride (75-44-5)</p> <p>Blood Agents Cyanogen chloride (506-77-4) Hydrogen cyanide (74-90-8)</p>
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* This list is representative and not all inclusive.

** The C.A.S. number is the Chemical Abstract Service Registry Number, a unique number based on chemical structure.

Figure 3.0-2. Selected Toxic Chemicals Requiring Detection, Warning, Identification, and Defense*

SECTION 3.1—CHEMICAL AND BIOLOGICAL DEFENSE SYSTEMS

OVERVIEW

The U.S. chemical and biological defense program includes contamination avoidance, individual and collective protection, and decontamination, all of which are addressed in this section. Contamination avoidance is based on sensors providing real-time detection and identification of toxic agents (see Section 3.2). The goal of individual and collective protection is to insulate U.S. ground, air, and sea forces from CB agents using clothing ensembles and respirators for individuals and collective filtration systems for groups. Additional precautions can be taken for biological agents such as immunization prior to exposure and antidote treatments after exposure provided the threat agents can be identified. Military requirements for individual protection are much more stringent than those used in commercial applications. Manufacturers deal with known processes, inputs, and outputs. The military must be prepared to respond to unknown threats including new agents in unknown quantities anywhere, and at any time. Since many types of protective gear limit human performance, sometimes up to a 50-percent reduction in capabilities, more advanced efforts are aimed at accounting for these limitations and increasing the comfort/wear time and freedom of action. Decontamination technologies that ensure rapid and effective force reconstitution are also included. Modeling and simulation are used for hazard assessment, weapons effects, and the results of decontamination.

Table 3.1-1. Chemical and Biological Defense Systems Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
PRODUCTION AND DESIGN TECHNOLOGY FOR PROTECTIVE MASKS - BIOLOGICAL	Provide protection against aerosol particles in the 0.1 to 10 micrometer range	Butyl rubber, silicon rubber; plastics	Simulated agents; leakage testers; mannequin - face model for mask and suit design; particle-size analysis equipment	Software for generating facial contours	WA ML 7, 21, 22 WA Cat 1B, D, E USML X
PRODUCTION AND DESIGN TECHNOLOGY FOR PROTECTIVE MASKS - CHEMICAL	Provide protection for 24 hrs against 10,000 mg-min/m ³ challenge for toxic vapors, aerosols	Butyl rubber Silicone rubber plastics	Simulated agents; Leakage testers; mannequin-face model for mask and suit design; particle-size analysis equipment	Software for generating facial contours	WA ML 7, 21, 22 WA Cat 1B, D, E USML X
PRODUCTION AND DESIGN TECHNOLOGY FOR PROTECTIVE CLOTHING - CHEMICAL	Provide protection for 24 hrs against 10 g/m ² challenge by all liquid agents and 10,000 mg-min/m ³ for toxic vapors, aerosols	Impregnated activated carbon (charcoal); Charcoal activated cloth; semi-permeable membranes; polymers	Simulated agents; particle-size analysis equipment	None identified	WA ML 7, 21, 22 WA Cat 1B, D, E USML X
PRODUCTION AND DESIGN TECHNOLOGY FOR COLLECTIVE PROTECTION - BIOLOGICAL	Provide protection against aerosol particles in the 0.1 to 10 micrometer range	Teflon/Kevlar laminate for biological resistance, decontaminability and environmental durability	Simulated agents	None identified	WA ML 7, 21, 22 WA Cat 1B, D, E USML X

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Table 3.1-1. Chemical and Biological Defense Systems Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
PRODUCTION AND DESIGN TECHNOLOGY FOR COLLECTIVE PROTECTION - CHEMICAL	Prevent > 99.9% of toxic agents from entering common areas	Impregnated carbon filters; polyethylene; fluoropolymer/aramid laminate	Simulated agents	None identified	WA ML 7, 21, 22 WA Cat 1B, D, E USML X
DECONTAMINATION - BIOLOGICAL	Sieve or remove 0.1 to 10 micrometer particles	Filter system to remove 0.1 to 10 micrometer particles by sieve action	Simulated agents	None identified	WA ML 7, 21, 22 WA Cat 1B, D, E USML X
DECONTAMINATION - CHEMICAL	Remove > 99.9% of toxic material or neutralize it	AMBERGARD XE-555 resin; sodium hydroxide); Super-Tropical Bleach (STB)	Simulated agents	None identified	WA ML 7, 21, 22 WA Cat 1B, D, E USML X

SECTION 3.2—DETECTION, WARNING, AND IDENTIFICATION

OVERVIEW

Technologies used for detection, warning, and identification of toxic chemical and biological agents are included in this section. Detectors used at designated locations are called point detectors. Standoff detectors provide early, wide area warning of an attack. Detection technologies must be capable of sensing and mapping large areas of non-volatile liquid chemical agent contamination and to be able to rapidly discriminate and identify biological agents. For biological agents, detection and warning systems are based on physical or chemical properties of these agents. Identification systems use immunochemical or gene probe techniques or mass spectral analysis. No single sensor detects all chemical or biological agents of interest. Detectors for toxic agents must have a short response time with a low rate of false returns and meet appropriate size, weight, and power requirements. Detection equipment must be integrated with a command and control system to ensure an alarm is disseminated. This is essential for contamination avoidance. Other unknown factors include location, duration, and intensity of the agent, which are crucial parameters for command decisions. Current DoD emphasis is on multiagent sensors for biological detection and standoff CB detection. The technology focus is on detection, warning and identification across the spectrum of CB agents as well as on the integration of CB detectors into various platforms, individual clothing and the C³I network. Identification is critical to medical response.

Table 3.2-1. Detection, Warning, and Identification Militarily Critical Technology Parameters

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
IMMUNO BASED - BIOLOGICAL	Capability of detecting 100 organisms of Australia Group agents.	Antibodies directed against Australia Group list agents	Antibody development	None identified	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
GENE BASED PROBE - BIOLOGICAL	Capability of detecting 100 organisms of Australia Group agents.	Polynucleolides complementary to Australia Group gene sequences; polymers	Gene sequence data	None identified	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
MOLECULAR RECOGNITION (E.G. ANTIGENS, ANTIBODIES, ENZYMES, NUCLEIC ACIDS, OLIGOMERS, LECTINS, WHOLE CELLS, RECEPTORS, ORGANELLES) - BIOLOGICAL	Capability of detecting 100 organisms of Australia Group agents. Can recognize weapons grade agent, by-products of its preparation or manufacturing signatures; does not recognize normally occurring environmental materials.	Antibodies directed against Australia Group list agents or polynucleotides complementary to Australia Group gene sequence	Coatings, films or fibers of biopolymers or chemical polymers that bind BW agents (binding K_d less than 1×10^{-8})	Molecular modeling databases (e.g. protein and DNA sequencing)	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
ION MOBILITY SPECTROMETRY (IMS) - BIOLOGICAL	Detecting several thousand organisms.	None identified	Database development; Ion source Spectroscopy capable of concentrating and analyzing 1000 organisms	Spectrum recognition algorithms	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E

(Continued)

Table 3.2-1. Detection, Warning, and Identification Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
ION MOBILITY SPECTROMETRY (IMS) - CHEMICAL	Capable of scanning samples of 10,000 daltons or less in 5 minutes or less.	None identified	Database development; Ion source	Spectrum recognition algorithms	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
MASS SPECTROMETRY - BIOLOGICAL	Capable of scanning samples of 10,000 daltons or less in 5 minutes or less.	None identified	Database development Portable, field rugged mass spectroscope	Spectrum recognition algorithms	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
MASS SPECTROMETRY - CHEMICAL	Capable of scanning samples of 10,000 daltons or less in 5 minutes or less.	None identified	Database development	Spectrum recognition algorithms	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
PASSIVE IR - CHEMICAL	Detects vapors at distances up to 5 km (Nerve: 90 mg/m ² , blister: 500 mg/m ² for L and 1500 mg/m ² for HD).	None identified	Database development	Spectrum and background recognition algorithms	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
TRANSDUCERS (E.G., OPTICAL, ELECTROCHEMICAL, ACOUSTIC, PIEZOELECTRIC, CALORIMETRIC, SURFACE ACOUSTIC WAVE (SAW); FIBER OPTIC WAVE GUIDE) - BIOLOGICAL, CHEMICAL	Converts recognition of agents to an optical or electrical signal. Low hysteresis. Optical/electronic component processing must be <1 second.	Antibodies and gene sequences for Australia Group list agents	Production equipment configured for the detection of biological agents	Spectrum recognition algorithms	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
SAMPLE COLLECTION (E.G. AIR, LIQUID, DUST, SOIL SAMPLING) - BIOLOGICAL	Collects and concentrates 1–10 micrometers particles into liquid medium.	None identified	Aerosol samplers able to collect less than or equal to 10 micrometers diameter particles into a liquid	None identified	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
SAMPLE COLLECTION (E.G. AIR, LIQUID, DUST, SOIL SAMPLING) - CHEMICAL	Collects and concentrates 1–10 micrometers particles into liquid medium.	None identified	Aerosol samplers able to collect less than or equal to 10 micrometers diameter particles into a liquid.	None identified	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E

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Table 3.2-1. Detection, Warning, and Identification Militarily Critical Technology Parameters (Continued)

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Export Control Reference
SAMPLE PROCESSING (E.G. CELL DISRUPTION, CONCENTRATION, PURIFICATION OR STABILIZATION) - BIOLOGICAL	Completion within 10 minutes.	None identified	Neg. pressure orifice devices for rupturing cell membranes or wall/retention of nucleic acids; impact collectors; ion trap mass spectrometers capable of scanning samples below 10,000 daltons in 5 minutes or less; pyrolyzers.	Spectrum recognition algorithm	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E
SAMPLE PROCESSING (E.G. CONCENTRATION) - CHEMICAL	Completion within 10 minutes.	None identified	Ion trap mass spectrometers capable of scanning samples from 40 to 1024 daltons in milli- secs; pyrolyzers; chemical and enzyme detection kits.	Spectrum recognition algorithm	WA ML 7, 21 WA Cat 1A, D, E USML XIV CCL Cat 1A, D, E