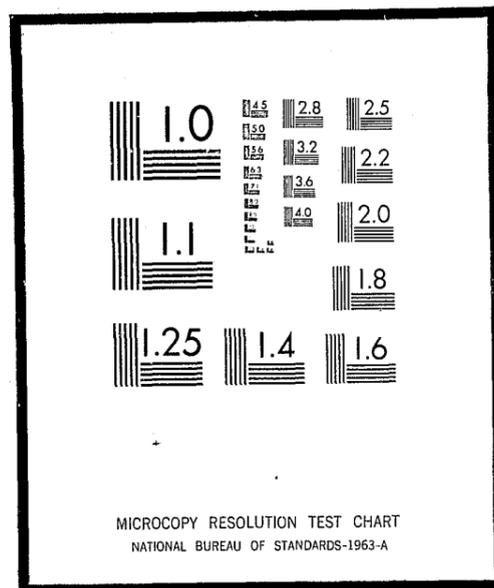


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U.S. DEPARTMENT OF JUSTICE
LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
NATIONAL CRIMINAL JUSTICE REFERENCE SERVICE
WASHINGTON, D.C. 20531

Date filmed

10/8/75

WASHINGTON OPERATIONS

DETAILED REQUIREMENTS ANALYSIS FOR PROTECTIVE GARMENTS

DECEMBER 1973

Equipment Systems Improvement Program Report
prepared for



U.S. DEPARTMENT OF JUSTICE
LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
NATIONAL INSTITUTE OF LAW ENFORCEMENT
AND CRIMINAL JUSTICE

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MITRE

REPORT

055

THE MITRE CORPORATION
WASHINGTON OPERATIONS

THE EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

WORKING PAPER

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Following a Congressional mandate* to develop new and improved techniques and equipment to strengthen law enforcement and criminal justice, the National Institute of Law Enforcement and Criminal Justice under the Law Enforcement Assistance Administration of the Department of Justice established the Equipment Systems Improvement Program. The objectives of the Program are to determine the priority needs of the criminal justice community to help in its fight against crime, and to mobilize industry to satisfy these needs. A close working relationship is maintained with operating agencies of the criminal justice community by assigning systems analysts to work directly within the operational departments of police, courts and corrections to conduct studies related to their operational objectives.

This document is a research report from this analytical effort. It is a product of studies performed by systems analysts of the MITRE Corporation, a not-for-profit Federal Contract Research Center retained by the National Institute to assist in the definition of equipment priorities. It is one of a continuing series of reports to support the program decisions of the Institute relative to equipment development, equipment standardization and application guidelines. Comments and recommendations for revision are invited. Suggestions should be addressed to the Director, Advanced Technology Division, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U. S. Department of Justice, Washington, D. C. 20530.

Gerald M. Caplan, Director
National Institute of Law
Enforcement and Criminal Justice

Subject: Detailed Requirements Analysis
for Protective Garments

To: W.E. Holden

Contract No.: F-19628-74-C-0001

Sponsor: LEAA/NILECJ

From: R.S. Carper

Project No.: 8160

Dept.: D-38

Page 1 of 35 Pages

Date: December 25, 1973

Approved for MITRE Distribution:

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ABSTRACT:

The data supporting the detailed operational requirements for police protective garments (presented in MITRE MTR-6534) are described in this working paper. This data includes results from prior studies by other organizations and new data from a recent survey of police departments. The data defines the type of weapons and level of threat. In addition, data establishing comfort/maneuverability requirements for everyday wearing of protective garments is presented.

* Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended.

THIS INFORMAL PAPER PRESENTS TENTATIVE INFORMATION FOR LIMITED DISTRIBUTION.

EXECUTIVE SUMMARY

During late 1972, the National Institute of Law Enforcement and Criminal Justice initiated a program to develop prototype protective garments for public officials and law enforcement officers. These garments were designed to protect the wearer against unexpected attacks by offenders armed with handguns or knives. Certain synthetic fiber materials, developed by Du Pont and known as Kevlar-29, PRD-TL-105, PRD-49, and PRD-400 were shown to resist the penetration by .38 caliber gunfire. Tests conducted by the U.S. Army Land Warfare Laboratories¹ showed that goats could survive .38 caliber gunfire at close range if they were protected by a 9-ply layer of PRD-TL-105-26 material. Operational requirements for police protective clothing made of this material were subsequently prepared by the MITRE Corporation.² This document summarizes the data from which these operational requirements were derived.

Data compiled by the FBI and the IACP on assaults upon police officers which resulted in fatality or serious injury are presented. Recent data on assaults upon police officers, obtained from the Atlanta, Chicago, and Detroit Police Departments, are also presented. The results of interviews with key personnel in the above police departments and with personnel in the New York City Police Department Firearms Section are summarized.

The results show that the major weapons threat is the .38 caliber, .32 caliber, .25 caliber, and .22 caliber handgun. The data indicate that a minimum of 67% of all of the weapons used against police are handguns, of these types. A survey of wounds and severity of wounds indicate that 57% of fatal wounds are to the torso, the area of the body that would be protected by the proposed garments. It is estimated that protective garments capable of affording protection against the .38 caliber handgun or lesser type weapons could provide a reduction of 38% in the number of police fatalities. Protective garments capable of stopping a .45 caliber handgun assault could effect a 50% reduction in the number of police fatalities. This assumes continued use of relatively inexpensive ammunition and firearms against the police.

¹ Aerospace Corporation Report 1279-RPK-73-039, dated 6 April 1973, to the National Institute of Law Enforcement and Criminal Justice.

² MITRE Technical Report MTR 6534, Detailed Operational Requirements for Protective Garments for Law Enforcement Agencies, 19 October 1973.

Data on the distribution of temperature/relative humidity comfort-index values, and on current wearability specifications for police uniforms suggest that protective garments must be capable of sustained wear for at least 80% of the duty tour in temperatures of 90° F and 50% relative humidity. The use of air-conditioned vehicles would have to be considered if police officers are expected to wear protective garments continuously in excess of 80° F and 60% relative humidity. In addition:

- There must be nothing to indicate to the observer that the police officer is wearing a protective garment.
- There must be minimal restriction of mobility and maneuverability.
- There must be wearability factors equal to that of conventional clothing.

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I. INTRODUCTION

This document presents the supporting material for MITRE Technical Report MTR-6534, Detailed Operational Requirements for Protective Garments for Law Enforcement Agencies. It contains the results of the investigative efforts to establish the level of threat, protection requirements, physical mobility requirements, comfort and appearance requirements, and serviceability requirements. To relate the justification of requirements as published in MTR-6534, this report will be structured in the same general format.

The investigative efforts described in this report were conducted from June through October, 1973. They consisted of both extensive review of police assaults data and in-depth interviews with police officials. Work was performed at several selected police departments as well as the MITRE field sites and at various national and federal agencies. The objective of these investigative efforts was to determine what a cross-section of typical police departments needed in the way of protective garment equipment that could be worn as an everyday part of the policeman's clothing. This led to the set of operational requirements for police protective garments published in MITRE MTR-6534.

II. DETERMINATION OF THE LEVEL OF PROTECTION

The determination of the level of protection was carried out on the basis of an extensive analysis of the weapons threat.

The weapon threat was assessed using a number of different sources. The National Police Casualty Analysis Program of the International Association of Chiefs of Police (IACP) was one such source of information. The Uniform Crime Reporting (UCR) Section of the FBI supplied a breakdown of the weapons involved in police fatalities for 1971 and 1972. Finally, the review of the records of the Detroit, Atlanta, and Chicago Police Departments yielded representative information pertaining to the types of weapons used in assaults on police. Additional data on weapons "on the street" were obtained from statistics kept by the Firearms Section of the New York City Police Department.

These sources lead to the conclusion that the most prevalent threat is the handgun and, specifically, the relatively inexpensive handgun. These principally are the .22 caliber, .25 caliber, .32 caliber, and .38 caliber weapons.

NATIONAL POLICE CASUALTY ANALYSIS PROGRAM

The International Association of Chiefs of Police maintains a Police Casualty Analysis Unit as a part of its Police Weapons Center. This group, in 1970, began collecting and analyzing data concerning police casualties, using a data source independent from that of the UCR program of the FBI. The initial report of this project¹ which covered the period from July 1, 1970, to June 30, 1971, found the handgun to be the largest single factor in causing police fatalities and severe injuries. Table I was compiled from the published report.

From this table, the handgun is shown to be the cause of at least 68 percent of the reported police deaths and 70 percent of the wounds requiring hospitalization in that study period. It could be safely assumed that handguns in the unidentified and severity unknown categories would raise these percentages.

¹ Batissta, Barry L. and Gary S. Persinger, Annual Law Enforcement Casualty Summary, July 1970 to June 1971, International Association of Chiefs of Police, Gaithersburg, Maryland.

TABLE I
RELATIONSHIP OF TYPE OF WEAPON TO SEVERITY OF WOUNDS

Severity Weapon	Killed	Wounded Hospitalization Required	Wounded Hospitalization Not Required	Severity Unknown	Total
Handgun	72	181	65	12	330
Rifle	10	11	8	3	32
Shotgun	10	24	31	1	66
Unidentified Firearm	9	23	15	2	49
Knife	4	20	61	6	91
Totals	105	259	180	24	568

Source: National Police Casualty
Analysis Program, IACP

UNIFORM CRIME REPORTING SECTION, FBI

The Uniform Crime Reporting Section of the FBI collects and publishes data from nearly every major city police department with respect to police assaults. In addition to compiling official statistics on the assaults, the UCR section of the FBI has also compiled unofficial statistics on the caliber and type of weapons used in police fatalities. These data are shown for 1971 in Table II and for 1972 in Table III. These tables indicate that in both years, there was a total of 168 handgun deaths. Of these, at least 126 were caused by .38, .32, .22, and .25 caliber weapons. This group of weapons constituted 75 percent of all fatalities caused by handguns.

SURVEY OF VARIOUS POLICE DEPARTMENTS

The types of firearms and knives used in assaults on police were investigated in detail at the Detroit, Atlanta, and Chicago Police Departments. A total of 107 reported assaults on police officers in Detroit in 1972 via firearm or cutting weapon were documented, as were 103 assaults in Atlanta and 119 assaults in Chicago during the same year. These assaults ranged from simple assault by weapon threat to actual fatality. Table IV indicates these findings. The assaults considered in the survey were only those where a definable weapon was employed. Other types of assaults, such as hands, feet, fists, clubs, or thrown objects were not included.

The composite results of these three-city findings indicate that handguns were reported in 66% of all police assaults, with knives accounting for another 19%. Of the 137 handguns identified from police reports, the following distribution was observed:

- .38 caliber - 37%
- .32 caliber - 19%
- .22 caliber - 28%
- .25 caliber - 10%
- .45 caliber - 4%
- .380, .357 Magnum } 3%
- .44 Magnum, .9mm }

TABLE II

LAW ENFORCEMENT OFFICERS KILLED BY FIREARMS - 1971

<u>Handguns</u>		<u>Rifles</u>		<u>Shotguns</u>	
.38 caliber	37	.22 caliber	5	12 gauge	6
.32 caliber	14	.30 caliber	2	16 gauge	1
.22 caliber	12	.32 caliber	1	20 gauge	1
.25 caliber	9	.35 caliber	1	Not stated	3
.45 caliber	5	30-30	1		
.380 caliber	3	.8 mm Mauser	1		
.357 Magnum	3	30-06	1		
.22 caliber Derringer	2	.308 caliber	1		
.44 Magnum Rueger	1	7.35 mm Italian carbine	1		
.9 mm Luger	1	AR-15	1		
.9 mm Browning	1	Not stated	1		
German Rohn	1				
Not stated	5				
Total	94		16		11

Source: Uniform Crime Reporting
Section, Federal Bureau
of Investigation
Washington, D.C.

TABLE III

LAW ENFORCEMENT OFFICERS KILLED BY FIREARMS - 1972

<u>Handguns</u>		<u>Rifles</u>		<u>Shotguns</u>	
.38	35	.22 caliber	4	12 gauge	14
.357 Magnum	13	.30 caliber	4	16 gauge	2
.22 caliber	10	30-30	2	20 gauge	2
.32 caliber	5	.308 caliber	2		
.25 caliber	2	30-40	1		
.45 caliber	1	.44 caliber	1		
.44 caliber	1	.35 caliber	1		
.380 caliber	1	M-1	1		
7.65 caliber	1				
.9 mm Luger	1				
Not stated	4				
Total	74		16		18

Source: Uniform Crime Reporting
Section, Federal Bureau of
Investigation
Washington, D.C.

TABLE IV

WEAPONS IDENTIFIED IN ASSAULTS ON POLICE OFFICERS

City	Detroit	Atlanta	Chicago	Composite 3-City
<u>Handgun</u>				
.38 caliber	12	9	29	50
.32 caliber	5	13	8	26
.22 caliber	9	18	11	38
.25 caliber	3	5	5	13
.45 caliber	3	0	3	6
.380 caliber	1	0	1	2
.357 Magnum	1	0	0	1
.44 Magnum	0	0	0	0
9MM automatic	1	0	0	1
not identified	<u>17</u>	<u>29</u>	<u>25</u>	<u>71</u>
TOTAL	52	74	82	208
<u>Rifle</u>				
.22 caliber	5	1	1	7
.30 caliber	6	1	0	7
.32 caliber	1	0	0	1
.35 caliber	0	0	0	0
30-30	1	0	0	1
Other	<u>2</u>	<u>2</u>	<u>2</u>	<u>6</u>
TOTAL	15	4	3	22
<u>Shotguns</u>				
12 gauge	11	1	3	15
16 gauge	2	1	3	6
20 gauge	1	0	0	1
sawed off	0	2	5	7
Other	<u>2</u>	<u>1</u>	<u>0</u>	<u>3</u>
TOTAL	16	5	11	32
<u>Knife</u>				
Knife	20	17	23	60
<u>Other cutting weapon</u>				
Other cutting weapon	4	3	0	7
TOTAL ALL ASSAULTS	107	103	119	329

137
Identified

It can be shown from Table IV that 85% of the weapons threat in actual police assaults are knives or handguns, and of the handgun threat, nearly 93% of the weapons identified in the offense reports were the .22, .25, .32, and .38 caliber weapons.

The Firearms Section of the New York City Police Department has been monitoring the number, type, and caliber of weapons seized during arrests and other police activity within the city. Table V gives the compilation of these statistics. Over one-half of the weapons seized were .22 caliber; most of these were "Saturday Night Specials." The combined percentage of .38, .32, .25, and .22 caliber weapons seized amounted to 95% of the total amount of handguns seized.

CONCLUSIONS

The various findings thus indicate that protective garments must, as a minimum, withstand the .38 caliber, .32 caliber, .25 caliber, and .22 caliber handgun threat. Additional findings indicate they must withstand these weapons at a distance of essentially point-blank range to 30 feet. These are the distances that have been most frequently noted in the aforementioned studies of armed police assaults. At these distances, the velocities and impact energies of the various ammunition for these weapons is essentially muzzle velocity. Thus, the levels of threat must be stated in terms of the type of weapon and the most powerful type of ammunition commonly employed for that weapon. These are summarized as follows:

- .38 caliber handgun: The stopping power shall be for a bullet equivalent to Remington Catalog No. 2038, which has the following specifications:

Type/Style: Semi-jacketed, hollow point
 Weight: 125 grams
 Muzzle Velocity: 1,370 ft. per second, SAMI Specification*
 Energy: 520 ft. - pounds

* Sporting Arms and Manufacturing Institute test barrels - actual weapons may have lower energy values.

TABLE V

HANDGUNS SEIZED BY NEW YORK CITY POLICE DEPARTMENT
DURING A FOUR-MONTH PERIOD

<u>Weapon Caliber</u>	<u>Number Seized</u>	<u>% of Total Seizure</u>
.22	700	52
.25	176	13
.32	230	17
.38	172	13
.357 Magnum	7	1
.45	24	2
9 mm	10	1
.380	19	1
.455	3	*
.22 Magnum	1	*
7.62 mm	1	*
.41	1	*
.44 Magnum	2	*
.31 Percussion	1	*
.36 Percussion	2	*
.44 Percussion	1	*
Total	<u>1350</u>	<u>100%</u>

* Less than 1%

Source: New York City Police
Department Internal
Memorandum

- .32 caliber handgun: The stopping power shall be for a bullet equivalent to Remington Catalog No. 2632, which has the following specifications:

Type/Style: .32 (7.65mm) automatic pistol
Weight: 71 grams
Muzzle Velocity: 960 ft. per second } SAMI Specification*
Energy: 145 ft. - pounds

- .22 caliber handgun: The stopping power shall be for a bullet having the following specifications:

Type/Style: Soft point
Weight: 40 grams
Muzzle Velocity: 700 ft. per second } SAMI Specification*
Energy: 75 ft. - pounds

Although the data have indicated the 9mm handgun is not a significant cause of police fatalities and has not been observed in any abundance as yet, there is a feeling among some law enforcement officials, especially within the New York City Police Department, that use of this weapon may increase. Thus, as a desirable characteristic, protective garments should also be able to withstand the following threat:

- 9mm handgun: The stopping power shall be for a bullet equivalent to Remington Catalog No. 9071, which has the following specifications:

Type/Style: Jacketed, hollow point
Weight: 115 grams
Muzzle Velocity: 1,160 ft. per second } SAMI Specification*
Energy: 345 ft. - pounds

In addition, the protective garments must be capable of withstanding any stabbing or slashing movements made with a knife or other cutting instrument.

* Sporting Arms and Manufacturing Institute test barrels - actual weapons may have lower energy values.

III. DETERMINATION OF PROTECTION REQUIREMENTS

AREAS OF PROTECTION

The investigation of police casualties due to assaults included a study of the location and severity of the wounds. The initial information was derived from the Uniform Crime Reporting Section of the FBI and the IACP survey. The IACP survey, giving relationship between severity and location of wounds, is shown in Table VI.

TABLE VI
RELATIONSHIP BETWEEN LOCATION OF WOUNDS AND SEVERITY

Severity Location	Killed	Wounded Hospitalization Required	Wounded Hospitalization Not Required	Severity Unknown	Total
Head	24	28	34	1	87
Torso	44	101	19	1	165
Arms	0	29	63	9	101
Legs	1	34	21	3	59
Multiple	17	55	22	1	95
Unreported	19	12	21	9	61
Totals	105	259	180	24	568

Source: National Police Casualty
Analysis Program, IACP

Discounting the effect of multiple gunshot wounds which may consist of any combination of head, torso, arm, or leg wounds and also discounting the unreported location of wounds, 35% (24 out of 69) of the fatalities were as a result of head wounds and 64% were as a result of wounds in the torso area. Of the 192 cases of hospitalization-required wounds identified with specific parts of the body, 14.5% were from wounds to the head and 52.5% were as a result of wounds to the torso.

The FBI data categorized fatalities in terms of wounds received to the head, upper torso, and below the waist (which may have included the lower abdomen as well as the legs). Assuming from the IACP data that wounds of the legs produce few if any fatalities, the FBI data indicate that 43% of the fatalities are sustained via wounds to the head, while 57% of the fatal wounds were to the upper and lower torso. The data are shown in Table VII.

TABLE VII
LOCATION OF FATAL WOUNDS SUFFERED BY VICTIM OFFICER
FBI UNIFORM CRIME REPORT DATA, 1971

	Front	Rear	Total	Percent of Total
Head	37	11	48	43 %
Upper Torso	39	13	52	46
Below Waist	10	2	12	11
TOTAL	86	26	112	100 %

In the survey of police assaults in Detroit, Chicago, and Atlanta, the following data on severity of wound and location of wound on the body were compiled (Table VIII).

Reviewing this data, it can be seen that there were 22 wounds sustained to the torso area (shoulder, chest, midsection, and back). Of these, all but one required hospitalization. There were also 28 wounds sustained to the head and arms, 3 to the legs, and 1 where the location was not reported. Of the head wounds, the majority (8) were treated and released. These were the result of knife activity or of grazing action of gunfire. The 14 wounds to the arm were all sustained by the victim attempting to remove a knife from the assailant.

The number of torso wounds requiring hospitalization (21) was 67% of the total number of wounds requiring hospitalization (31). Comparing this to the FBI fatality data in Table VII and the approximation that 57% of the fatal wounds were to the upper and lower torso area, it may be concluded that the torso is an area of protection where roughly 60% in serious injury reduction is available through the use of protective garments covering the torso area.

PROJECTED REDUCTION IN FATALITIES

The Uniform Crime Reports show that there were 112 law enforcement officers killed in 1972 and 126 killed in 1971. Of these, 108 were slain with firearms in 1972 and 121 in 1971. In addition, two were killed with knives in each of the two years. The remainder were killed by automobiles, beatings, and bombs. Ninety-eight percent (233) of the fatalities in these years were due to gunshot and knife wounds.

The FBI data (Table VII) show that 57% of all fatalities were by wounds to the torso. Thus, of the 233 fatalities occurring in the two years (1971 and 1972), 133 might have been prevented by a protective garment which covered the torso area.

In Figure 1, a histogram (developed from the 1971 and 1972 FBI data) of the weapons used in officer fatalities is shown. The types of firearms are arranged in increasing potential to penetrate garment material (based on the use of common lead point ammunition in the weapons). A garment designed to provide protection against the full range of threats shown in Figure 1 would be by design both bulky and heavy in its present state of development. Such a garment would not likely be worn by law enforcement officers in routine operations. It would defeat the purpose of providing protection

TABLE VIII

SEVERITY, AND LOCATION OF BODY OF WOUNDS, 1972 POLICE ASSUALTS

Severity Part of Body Receiving Wound	Killed				Wounded, Seriously, Victim Immobilized and Hospitalized				Wounded, Victim Not Immobilized but Hospitalized after Attack				Wounded Slightly, Victim Not Immobilized, Treated & Released at Hospital				Total Wounds
	Detroit	Atlanta	Chicago	Total	Detroit	Atlanta	Chicago	Total	Detroit	Atlanta	Chicago	Total	Detroit	Atlanta	Chicago	Total	
Head	2		1	3	1			1	2			2	3	3	2	8	14
Arm										1		1	7	2	4	13	14
Shoulders									2	3	1	6	1			1	7
Chest - Left					1			1			1	1					2
Middle					2		2	4									4
Right											1	1					1
Midsection-Left																	1
Center			1	1	1			1	1			1					3
Right											1	1					0
Upper Back-Left					1			1									1
Right																	0
Lower Back-Left					1			1	2			2					3
Right																	0
Groin																	0
Legs									1		1	2	1			1	3
Unknown									1			1					1

22

14

during normal duty operations. During the period 1968 to 1972, over 75% of the fatalities were among patrol officers as contrasted to less than 25% among detectives and specially assigned officers (Uniform Crime Reports, 1972). Only a small fraction of the 25% would have been in an operational situation where heavy armor could have been employed for a protection. In order to have major impact on officer fatalities, the garment must be such that it is readily available to and can be worn comfortably by law enforcement officers in the normal course of their duties.

It appears that a garment capable of withstanding the penetration of weapons up to and including .38 caliber handguns can be produced which will be comfortable and not interfere with the officer's normal functions. From Figure 1, it is shown that such a garment would provide protection against 67% of the threat as measured for the 1971-1972 period.

Earlier it had been estimated that 57% of the fatalities were due to injuries to the torso (the area protected by the garment under consideration). If all the officers fatally wounded in the 1971-1972 period were wearing the vest, then there would have been 144 fatalities rather than 233--a reduction of 38%.

This assumes that the conditions present in the reference period (1971-1972) are not substantially changed, i.e., weapons distribution, injury distribution, use of armor piercing and exotic ammunition, etc. In addition to the prevention of fatalities, it is anticipated that the severity of non-fatal gunfire and knife injuries would be reduced by the garment and even in the case of higher threat weapons (above .38 caliber) there may be some reduction of the effect of gunfire from fatality to serious injury. This is based on the criteria for protection which specifies that the bullet will not pierce the garment and will not enter the body. An increase in effectiveness of the garment (if possible) to protect against threats up to and including .45 caliber weapons would encompass 77% of the threat and provide an overall 50% improvement in survival probability for an officer wearing the garment.

BLUNT TRAUMA RESISTANCE AND WEARER INCAPACITATION

In addition to protection from gunshot penetration, the protective garment is expected to withstand the impact of a bullet and to minimize the damaging effects of the non-penetrating energy distribution. The effect can be measured by two parameters: blunt trauma and wearer incapacitation. Blunt trauma effect is a measure of the physical damage suffered by the body as a result of the impact of a bullet or knife point striking the body but not being

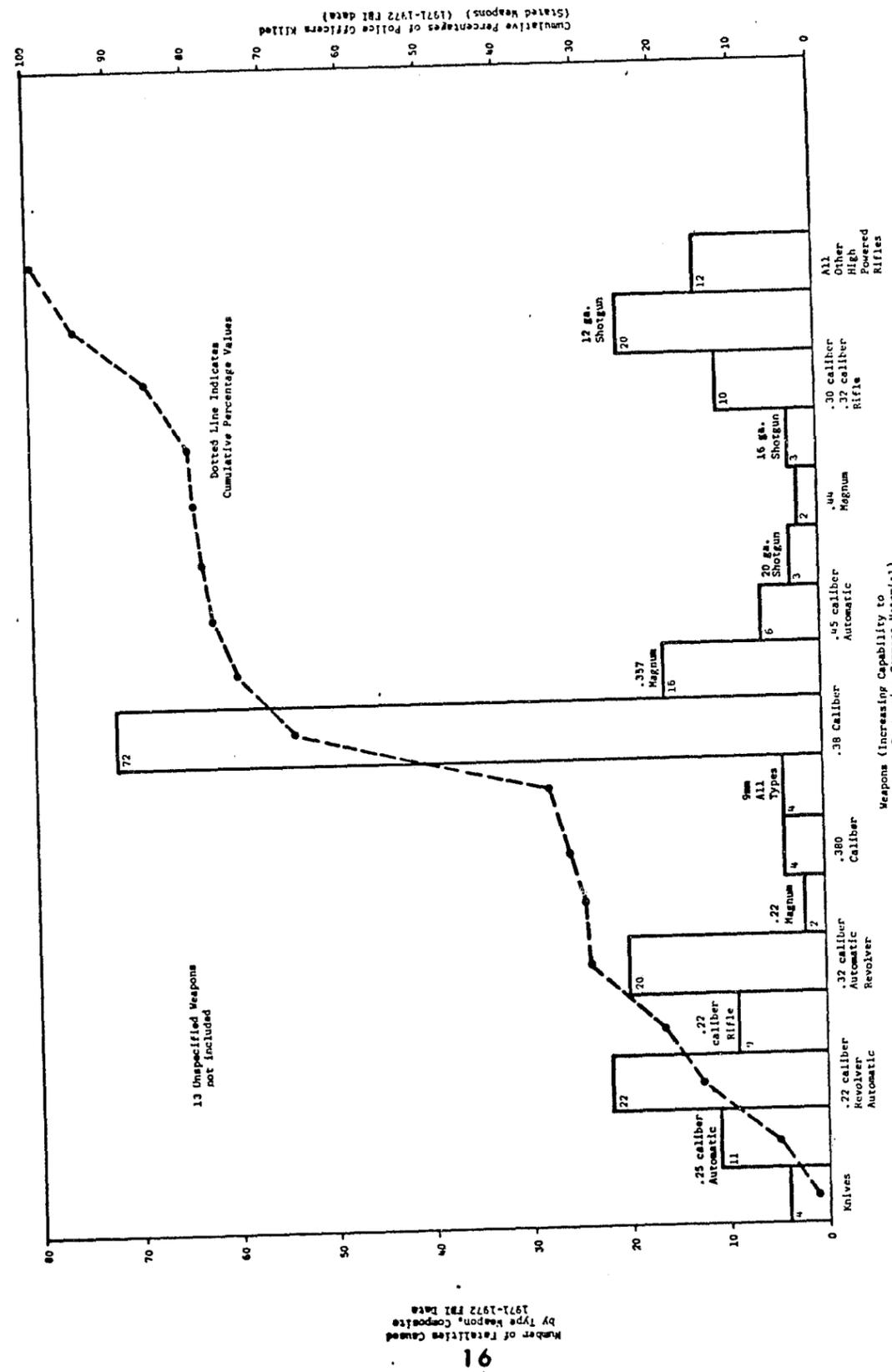


Figure 1
Cumulative Percentages of Police Officers Killed, 1971-1972 FBI Data, Grouped by Increasing Firepower Level of Weapon Used

allowed to penetrate the protective garment being worn. Wearer incapacitation is a measure of the degree to which the victim is knocked unconscious or his reflexes are stopped as a result of the impact of the bullet striking the protective garment.

Maximum blunt trauma effect could be exemplified by internal injuries so severe that the victim dies, even though no bullet has penetrated the protective garment.

The determination of the acceptable levels of wearer incapacitation and blunt trauma resistance were arrived at through a survey of various police departments by MITRE field site representatives, and presented in an earlier working paper (WP-10280). These indicated the following:

1. The officer must be able to defend himself against further attack.
2. The officer must be fully conscious and able to continue to return the gunfire after the initial attack.
3. The pursuit of the assailant was not considered to be of prime importance.
4. The officer wearing a protective garment shall not suffer irreparable body damage as a result of blunt trauma induced by the ballistic impact of the bullet. Injury should at minimum be less severe than without protection.

IV. DETERMINATION OF PHYSICAL MOBILITY REQUIREMENTS

The construction of protective garments shall afford the wearer sufficient maneuverability so that his duties and responsibilities as a law enforcement officer will not be compromised or constrained in any manner. The operational requirements for maneuverability are based on the situational requirements of activities associated with police work. These requirements were stated by police departments where MITRE field sites have been established and have been confirmed by interviews held informally with the Chicago, Detroit, Atlanta, and New York Police Departments. Examples of these situational requirements are described as follows:

RUNNING

A police officer on active patrol assignment may be required to run in pursuit of a fleeing suspect. Protective garment material must, therefore, not impede a law enforcement officer in running.

PHYSICALLY SUBDUING AN ADVERSARY

Protective garment material must not constrain a law enforcement officer in physically subduing an adversary.

ABILITY TO DRAW WEAPONS

There shall be no increase in the time required for a police officer to draw his service revolver either from a holster mounted externally on his uniform belt or concealed within his regular belt if he is wearing a street-type clothing.

RESCUE/CLIMBING

Protective garment material shall not constrain a law enforcement officer in carrying out any activity associated with rescue or other emergency incidents.

V. DETERMINATION OF COMFORT/APPEARANCE REQUIREMENTS

COMFORT

The initial protective garment survey² conducted at the MITRE Field Sites, indicated that the individuals contacted in these police departments wanted a garment that would be comfortable in both winter and summer conditions; and inconspicuous to the casual observer.

Under summer conditions, the addition of extra clothing to the police uniform might present a problem. In some parts of the country, particularly the Gulf Coast and the Southwest, the summer heat and humidity would dictate the lightest weight, most comfortable clothing possible. Thus, it was necessary to examine these climatological effects to see what effect they might have in limiting the extent to which protective garments would be worn.

The National Climatological Center of the National Oceanic and Atmospheric Administration (NOAA) had developed a Temperature-Humidity Index which is an indicator of the discomfort caused by various combination of dry bulb temperature and percent relative humidity. It is computed as follows:

$$THI = 0.4 T_{DB} + T_{WB} + 15$$

where T_{DB} = dry bulb temperature, °F T_{WB} - wet bulb temperature °F.

According to the National Climatological Center, at a THI of 75, a majority of people will be uncomfortable. A THI value of 80 indicates that almost everybody will be very uncomfortable. Table IX gives the THI values of 75 and 80, respectively for various temperature-relative humidity combinations.

It was desired to determine the geographical and temporal distribution of THI values exceeding 75 and 80 as a measure of the extent to which adverse temperature-humidity conditions might affect the wearing of protective garments in everyday police duty. The longer the continuous period of time THI values are excessive, the more difficult would be the outdoor climatic conditions for a police officer operating in a non-air conditioned environment.

² WP-;0280: Protective Garments for Police; Preliminary User Opinion Survey; 25 May 1973.

TABLE IX
THI INDEX

Temperature	Relative Humidity	
	Borderline Discomfort (THI=75)	Everyone Discomfort (THI=80)
75	100	
76	91	
77	82	
78	75	
79	68	
80	61	
81	55	100
82	49	93
83	43	86
84	38	78
85	33	71
86	29	65
87	25	59
88	20	54
89	17	49
90	14	43
91	10	38
92	7	34
93	5	30
94	3	26
95	1	23
96	Uncomfortable at any humidity	20
97	↓	16
98		13
99		11
100		8
101		6
102		3
103		1
104	Extremely uncomfortable at any humidity	

Source: National Oceanic & Atmospheric Administration
National Climatological Center

To assess these conditions, a sample of six cities was selected and the daily local climatological conditions, as reported by the National Climatological Center of the National Oceanic and Atmospheric Administration (NOAA) for a given year (1967) were evaluated in terms of THI values. The data for Los Angeles, Phoenix, Houston, Miami, Kansas City, and Minneapolis were reviewed. The number of days per month where THI values were 75 or over for periods ranging from three to nine hours or more was tabulated.

The data appear in Table X. It can be seen that in cities such as Miami, Houston, and Phoenix, the summer months experience 20 to 30 days where THI values of 75 exist for continuous periods of nine hours. In Houston, half the month of July could be expected to have a THI value of 80 or more for a sustained period of nine hours or longer.

Thus, police departments in these areas would require a protective garment that could be worn comfortably most of the time in temperature-humidity ranges of 90-95° F at 50% relative humidity.

Table XI gives recommended percentages of duty tour for various temperature ranges/relative humidity conditions, based on the observation contained in the previous sections.

APPEARANCE

The police personnel contacted to date have indicated that the appearance of protective garments must not be obvious to a potential assailant. In addition, the protective garment must be acceptable to the established code of appearance and dress regulations for the given police agency. The police departments participating in this survey provided specifications used in uniform procurements. Nearly all of these specifications stressed neatness in stitching, pleats, creases, cutting and forming.

In applications where protective garment material would be used as inner linings for reefer coats, car coats, or uniform blouses, these existing uniform specifications would dictate the method by which these linings would be built into the given uniform components. These types of uniform components are not to differ in any respect from their counterparts that do not have protective garment material linings.

TABLE X
EVALUATION OF THI BASED ON LOCAL CLIMATOLOGICAL DATA

Number of Continuous Hours THI Value Reported	Borderline Discomfort THI ≥ 75				Extremely Uncomfortable THI ≥ 80			
	0-3	3-6	6-9	>9	0-3	3-6	6-9	>9
<u>Houston</u>								
January	0				0			
February	0				0			
March	8	4			0			
April	22	21	16	10	2			
May	23	21	17	12	9	9	1	
June	30	30	29	27	24	23	18	7
July	29	28	26	23	24	20	18	13
August	30	28	25	23	17	13	10	8
September	24	23	20	16	10	4		
October	14	13	7	3	1			
November	5	2			0			
December	0				0			
<u>Kansas City</u>								
January	0				0			
February	0				0			
March	1				0			
April	2	2	1		0			
May	5	4	4		0			
June	18	15	10	5	3	1		
July	19	18	17	14	11	9	7	
August	18	18	16	8	6	3	2	
September	7	3	1		0			
October	4	2	1		0			
November	0							
December	0							

TABLE X (Continued)
EVALUATION OF THI BASED ON LOCAL CLIMATOLOGICAL DATA

Number of Continuous Hours THI Value Reported	Borderline Discomfort				Extremely Uncomfortable			
	THI ≥ 75				THI ≥ 80			
	0-3	3-6	6-9	>9	0-3	3-6	6-9	>9
<u>Miami</u>								
January	12	7	5	1				
February	7	7	1					
March	10	9	3	1				
April	11	10	5	2				
May	27	26	22	17	3	1		
June	30	30	28	21	17	6		
July	31	30	30	30	18	10	1	
August	31	31	25	23	16	2		
September	30	30	28	26	14	8	2	
October	30	16	18	6				
November	7	3						
December	8	8	3					
<u>Los Angeles</u>								
January	0							
February	0							
March	0							
April	0							
May	2	1						
June	0							
July	2	1						
August	4	2						
September	3	2	1					
October	4	2						
November	0							
December	0							

TABLE X (Concluded)
EVALUATION OF THI BASED ON CLIMATOLOGICAL DATA

Number of Continuous Hours THI Value Reported	Borderline Discomfort				Extremely Uncomfortable			
	THI ≥ 75				THI ≥ 80			
	0-3	3-6	6-9	>9	0-3	3-6	6-9	>9
<u>Minneapolis/St. Paul</u>								
January	0				0			
February	0				0			
March	0				0			
April	0				0			
May	0				0			
June	4	4	3		0			
July	10	8	6	3	1	1		
August	5	4	3		0			
September	0				0			
October	2				0			
November	0				0			
December	0				0			
<u>Phoenix</u>								
January	0							
February	0							
March	0							
April	0							
May	15	12	7	2	4	3	1	
June	21	21	16	14	13	11	3	1
July	31	31	31	31	31	31	30	17
August	31	31	31	31	30	30	27	17
September	30	30	28	21	17	16	8	
October	12	9	4	1	2	2		
November	0							
December	0							

TABLE XI

MINIMUM PERCENT OF DUTY TOUR IN WHICH GARMENTS ARE EXPECTED TO BE WORN COMFORTABLY IN AN OUTDOOR, NON-AIR-CONDITIONED SETTING

TEMPERATURE (°F)	RELATIVE HUMIDITY (%)					
	50	60	70	80	90	100
70-75	100	100	100	100	100	100
75-80	100	100	95	95	90	90
80-85	95	90	85	85	80	75
85-90	85	80	80	75	70	65
90-95	80	70	65	60	50	40
95-100	60	50	40	30	-	-
ABOVE 100	40	20	-	-	-	-

In the case of protective undergarments or inner vests, these type of components should not alter the appearance of short-sleeve uniform shirts, civilian dress, or other clothing that is to be worn in the line of police duty. There must be no apparent outer stiffness, bulging, corset-like effect, or other indications that protective clothing is being worn underneath the uniform.

VI. SERVICEABILITY/MAINTAINABILITY REQUIREMENTS

The establishment of serviceability/maintainability requirements for protective garments has been made on the basis of practical application of clothing in rugged-duty service. The manufacture or construction of these garments must not be such that they will fail in normal police service by way of deficiencies. The protective garment material itself must be resistant to environmental or ambient conditions associated with both the general outdoors and the specific nature of police work. There also must not be any loss of protective qualities of the garment material after it has been in everyday wear, as opposed to the protective qualities exhibited under test by the material when new. The following subsections will describe these requirements.

AGING

Aging requirements are based upon factors such as an initially high cost of the garment material. This cost is reflected by the material itself and the specialized manufacturing necessary to fabricate the garments. As a result, a protective garment component should have a long period of service, relatively unaffected by any aging of the material. The period of time of ten years has been selected as that representing a reasonable goal.

MOISTURE

Moisture will be encountered in police service by perspiration in hot weather, accidental or intentional spillage of water, or rain. Protective garments should provide the required protection under these conditions.

TEMPERATURE

Law enforcement officials are expected to perform their duties over a wide range of temperatures and the garment should meet requirements over this range.

AMBIENT AIR POLLUTANTS

The garment must not exhibit any deficiencies in protective requirements when exposed to commonly existing pollutants.

SUNLIGHT

The ultraviolet ray properties of sunlight may affect synthetic material. Hence, there has been established a requirement that the material shall be unaffected by exposure to direct rays of the sun.

ABRASION

Clothing in police service is subject to abrasion due to the activity of the police officer on duty. The requirements for abrasion resistance for protective garments are similar to requirements imposed on conventional uniforms.

BODY CONTACT SUBSTANCES

Body salts from perspiration, cosmetics, alcohol, soaps, or other personal care items will come in contact with protective garment material as a normal result of being worn on the body. This requirement that the protective qualities shall not be deteriorated as a result of these substances is included to ensure that no degradation in garment performances will occur due to them.

POLICE CHEMICAL AGENTS

In addition to body substances and cosmetic material, there are certain chemical compounds used in police work. These include gun oils, mace, tear gas, fuel, or cleaning materials. Protective garment material should not be affected by them.

LAUNDERING AND DRY CLEANING

The factors for reduction in weight after laundering (wet washing, followed by forced air drying) in a commercial laundromat or home washer/dryer are established as comparable to conventional clothing material. Similarly, it is not expected that there will be any body odor retention or soil retention from these garments, since conventional material properly washed and dried should not retain odor or markings.

Increase in stiffness or bulkiness of protective garments will tend to increase the obtrusiveness of protective garments, particularly those designed to be worn over a tee shirt and underneath a short sleeve dress shirt. For this reason, the requirement has been established that there shall be no measured increase in bulkiness or protrusion in protective garments as a result of laundering or dry cleaning.

Since surface abrasiveness will reduce the degree of comfort in protective garments, surface abrasiveness has been specified as having only a minimal increase after 25 washing cycle.

SHRINKAGE

The shrinkage level comparable to that of "Sanforized" cotton has been used as the criteria for establishing this requirement.

STITCHING

The requirements for tensile strength and other seams have been specified as being comparable to stitching and seaming of conventional clothing to ensure that the garment will wear at least as well as a conventional uniform.

END