

**REPORT OF THE  
VIRGINIA DEPARTMENT OF LABOR AND INDUSTRY  
AND THE  
VIRGINIA COMMUNITY COLLEGE SYSTEM**

**The Need for a  
Public-Supported  
Training Program for  
Boiler Plant Personnel**

**TO THE GOVERNOR AND  
THE GENERAL ASSEMBLY OF VIRGINIA**



**HOUSE DOCUMENT NO. 11**

**COMMONWEALTH OF VIRGINIA  
RICHMOND  
1990**

REPORT OF THE  
DEPARTMENT OF LABOR AND INDUSTRY  
AND THE  
VIRGINIA COMMUNITY COLLEGE SYSTEM  
TO  
THE GOVERNOR AND THE GENERAL ASSEMBLY OF VIRGINIA

RICHMOND, VIRGINIA  
DECEMBER, 1989

TO: The Honorable Gerald L. Baliles, Governor of Virginia  
and  
The General Assembly of Virginia

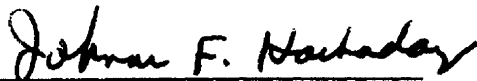
In February of this year, an evaluation was requested on the need for a public supported training program for boiler plant personnel in the Commonwealth and if such a program is needed, how such a program shall be established.

The report is transmitted pursuant to House Joint Resolution 371 of the 1989 Session of the General Assembly of Virginia. The findings and recommendations of the Virginia Department of Labor and Industry and the Virginia Community College System are reported herein.

Respectfully submitted,



Carol Amato  
Commissioner



Johnas F. Hockaday  
Chancellor

REPORT ON THE NEED FOR PUBLIC-SUPPORTED  
BOILER TRAINING

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## I. INTRODUCTION

### A. Background Information

This report has been prepared pursuant to House Joint Resolution 371 (HJR 371) passed by the Virginia General Assembly during the 1989 Session. This resolution requests the Department of Labor and Industry (DLI) and the Virginia Community College System (VCCS) to evaluate the need for a public-supported training program for boiler plant personnel in the Commonwealth. In addition, if it is determined that such a program is needed, the agencies shall determine how such a program shall be established.

### B. Purpose of the Study

The Department of Labor and Industry and the Virginia Community College System undertook a study which addressed the following issues:

1. The occupation of boiler operators and its changing nature;
2. The effect of this occupation on the public health, safety and welfare;
3. The extent of public protection afforded under the existing system of operator training;
4. The public need to have more qualified boiler operators;
5. The extent of public supported boiler training in other states.

This report serves to outline the results of the study, present findings, and recommend the most appropriate training program, if any, for this occupation.

### C. Study Rationale and Approach

The research utilized in this study consisted of the following:

1. Information and materials on existing training programs were gathered from a variety of professional and academic sources.
2. Data on historical and current demand as well as projected patterns of employment in the occupation were obtained from public sector, private sector and military sources.

3. Historical review of the incidence rate of boiler accidents nationally and in the Commonwealth was conducted.
4. Public comments were solicited from interested parties.

The above data was examined to evaluate the present state of the occupation in the Commonwealth. Subsequently, an analysis of the risk to the health, safety and welfare of the public and the overall performance of this occupational group was completed.

## II. KEY ISSUES

### A. Profile of the Occupation

The use of steam as a primary source of power was a catalyst for the Industrial Revolution of the eighteenth century. The development of the large steam generator made possible the electrical age of the twentieth century. Today, boilers provide the heat and energy that is needed to sustain industrial and residential applications in a power dependent society.

There are several classifications of boiler operators and various occupational types to identify operators of steam generators. Some of the more common titles are:

Auxiliary Equipment Operator	Power Plant Operator
Boiler Operator	Power Reactor Operator
Boiler Room Helper	Stationary Engineer
Firer	Steam Plant Operator

All of the above titles are primarily involved with the firing of steam or water boilers. Basic knowledge of the steam cycle is a requirement in all cases.

There have been boiler operators since Robert Fulton first demonstrated the practical advantages of steam power in his steamboat in 1807. Since that time, the occupation has been a specialized vocation with operators receiving primarily on-the-job training. Today, this occupational group is prevalent in many areas of general industry, government, hospitals, schools, and chemical plants. The occupation has gone through a transitional period of rapid evolution under the guidance of the power and combustion engineer, the mechanic and the operating engineer.

This evolution is most clearly visible in the increasing sophistication of the profession with the addition of automatic controls and safety equipment which have been developing since the turn of the

century. The basic theory of steam production, however, has remained the same. The demand for higher pressures and temperatures has brought the industry into the nuclear age with more advanced technology of steam production being utilized.

Present day applications for boiler operators range from the operation of small cast iron heating boilers in apartment houses and schools to the multi-story utility boilers in power plants.

#### B. Public Health, Safety and Welfare

The unsafe or improper operation of boilers can have a profound impact on public safety. Depending on the size, operating pressure and operating temperature of the unit, boiler explosions have the potential to completely destroy a building and may cause damage to structures as far as one mile from the location of the explosion. Public safety requires the proper operation of boilers within the specified design range established by the boiler manufacturer, and the periodic safety inspections of the boiler's internal condition and testing of the safety appurtenances.

The welfare of the public depends on the competent action of operators who can not only safely operate boilers but also react immediately and efficaciously in emergency situations.

#### C. Availability of Current Training Sources

At present, there are a number of sources for training boiler and pressure vessel operators, each providing qualified operators.

##### 1. Military

The largest training course for boiler and pressure vessel operators is the United States Naval Training Center, Great Lakes, Illinois, where 1,400 to 2,000 boiler technicians are trained annually. These military personnel are subsequently placed aboard ships or on military base facilities to operate high pressure boilers, auxiliary machinery and pressure vessels.

2. Commercial Manufacturers

Most large boiler manufacturers have boiler operator training courses for companies who purchase their boilers. They train the purchaser's operators to operate their specific type of boiler and equipment.

3. Insurer

The largest boiler insurer in the United States is The Hartford Steam Boiler Inspection and Insurance Company of Hartford, Connecticut. This company offers six training courses per year throughout the United States. A one-day course of instruction on boiler operation and maintenance is offered at a cost of \$225 per person. In 1989, these courses are being presented in Atlanta, Washington, D.C., Cincinnati, Anchorage, Hartford and Seattle.

4. Professional Association

The National Association of Power Engineers (N.A.P.E.) of Des Plaines, Illinois, present training to applicants five times a year at various locations throughout the United States. A two-day course of instruction, at a cost of \$200 per person, can train thirty to forty applicants at each session. In 1989, courses will be presented in Atlanta, Binghamton, Columbus, Los Angeles, and Milwaukee.

The N.A.P.E. course is considered to be one of the most beneficial training courses. It assists boiler operators in passing the certification examination administered by some local jurisdictions based on the National Institute for the Uniform Licensing of Power Engineers' (NIULPE) Examination.

5. Academic

Several colleges and universities (including Pennsylvania State University, Bearney Campus, and Gannon University in Erie, Pennsylvania) provide training courses for boiler operators. Within the Commonwealth, there is an academic certificate program at Mountain Empire Community College in Big Stone Gap. Mountain Empire, however, has filed a discontinuation request with VCCS to drop the program from their active inventory due to insufficient enrollments.

#### D. Adequacy of Current Training Sources

At the present time, the national availability of trained boiler operators appears to be adequate with current training sources. In the Commonwealth, the supply of trained operators also appears adequate. From 1983 to 1987 the latest years for which data is available, the annual number of job openings received by the Virginia Employment Commission has been 25 or less. Although a large percentage of discharged military personnel with boiler training go into other fields, there appears to be a sufficient number of trained operators to fill the needs of the marketplace.

Major companies who utilize large boilers usually recruit boiler operators from their staff of maintenance mechanics or other engineering trades. These companies generally conduct on-the-job training for these operators. Most boiler units of substantial size today have automatic controls and safety devices. Operators are trained by other operators to handle problems with the specific type of boiler they utilize.

#### E. Action by Other States

At present, Arkansas, Minnesota, Montana, Nevada, New Jersey, Ohio and the District of Columbia require boiler operators to be trained through on-the-job service or certificates which verify the proper qualification and training of individuals.

### III. SUMMARY OF RESEARCH

#### A. Findings

In order to evaluate the degree to which operator error is a causal factor in boiler accidents, such occurrences must be reviewed historically.

In addressing the issues set forth in this report, this section will analyze data tables (Appendix B) compiled from the Annual Incidence Reports issued by the National Board of Boiler and Pressure Vessel Inspectors for the years 1983 through 1988 inclusive.

To develop an occurrence baseline for comparison with actual Commonwealth data for this period, U.S. incidence rates were applied to a volume of active objects equivalent to the number of such objects in Virginia for each year under consideration. The Commonwealth had approximately 72,000 active objects registered with the Department of Labor and Industry in



1988. This figure represents slightly less than 0.4% of the 18.5 million objects registered in the U.S. in this same period.

From 1983 to 1988, Virginia's accident rate attributed to operator error was 15.9%, comparable to the national rate of 15.3%. In addition, the actual number of boiler and pressure vessel accidents during this period from all causes was 69, or 22% lower than the 88 accidents that would be expected using the U.S. incidence rates. The number of accidents in the Commonwealth due to operator error was 15% lower than the national average.

During this period, the Commonwealth has experienced a total of 11 boiler accidents as a result of operator error for an average of less than two accidents per year. Of these 11 accidents due to operator error, a total of three injuries and zero deaths occurred.

The Virginia Occupational Information Coordinating Committee (VOICC) at the Center for Public Service, University of Virginia, indicates in the seventh edition of the Virginia Occupational Demand, Supply and Wage Information that little formal training is available for these occupations. The majority of boiler operators are trained in the schools of the U.S. Navy and receive their on-the-job training on board U.S. Naval ships.

A Notice to the Public regarding the need for training and requesting public comment was published in the May 22, 1989 issue of the Virginia Register of Regulations. In addition, a request for public comment concerning the need for public-supported boiler training was sent to a random sample of private and public sector organizations who are registered with the Boiler Safety Enforcement Division of the Department of Labor and Industry as having five or more active boiler objects.

Of the 1,100 letters sent out by DLI requesting comment, 32 responses were received: 22 in favor of a program, 9 opposed to a program and one which expressed no opinion.

This response rate of approximately 3% would appear to indicate a low interest in the subject or that the subject was not perceived as relevant. Such a low rate of return requires that data be treated with considerable skepticism in terms of representativeness.

A somewhat higher response rate of between 10% and 20% was anticipated. The group queried was expected to have some interest in or familiarity with the subject, identify with the goal of the study and be more motivated to respond.

In Virginia, this occupation is not licensed, nor is formal training required for employment. Therefore, an individual who is currently employed may have no incentive to receive such training. However, boiler operators with formal training can be expected to be in greater demand as they could reasonably be expected to provide greater efficiency in the use of resources and greater productivity on the job.

The development of a public-supported training program, may only be warranted if the public's health, safety and welfare is not being adequately addressed by the existing system. The concern here is not the public health or welfare in regard to sufficient and continued production of heat and power, but rather public safety from boiler and pressure vessel explosion.

Long term outlook for the profession is mixed. Of the various occupational titles which are encompassed by the generic term "boiler operator", slightly less than 50% of all individuals employed in these titles may be categorized under the lower skilled headings of "helper" and "firer" as opposed to "operator" or "stationary engineer". The helpers and firers, as a group, are most negatively impacted by the continuing automation of this occupation.

Over time, the decline in total growth of this occupation will accelerate as the helpers and firers are replaced by automated systems at a rate which is greater than that experienced by the more highly skilled groups within the occupation.

Total annual statewide openings, both new and existing, for this occupation have increased from 146 in 1984 to 172 in 1987, a gain of 28 positions during the period.

Total annual statewide employment is expected to increase from an estimated 2,702 boiler operators in 1984 to 3,262 in 1995, which represents a below average growth rate of just under 21%. This rate is significantly below the statewide average of 29% for all occupations.

## B. Conclusions

I. If it were to be assumed that any training program was 100% effective in eliminating boiler accidents due to operator error, it would appear difficult from a

benefit/cost perspective to justify such a program to eliminate an average of less than 2 accidents annually in a universe of 72,000 active boiler objects statewide.

II. In view of the limited number of accidents due to operator error, it is difficult to conclude that formal training would provide significant improvement in public health, safety or welfare.

III. This occupational group will, as a whole, become increasingly skilled, albeit smaller, through the functioning of the marketplace and continued automation.

IV. The number of individuals that could be expected to take advantage of public-supported training is difficult to quantify. The unique nature of many boiler installations coupled with varying levels of automated operation tends to somewhat mitigate the advantages of a classroom training program. Site specific on-the-job training would appear more desirable and effective.

V. Boiler operators with formal training can be expected to be more employable as they can provide greater efficiency in the use of resources and greater productivity on the job. As these benefits accrue almost exclusively to the individual and the employer, it is reasonable and appropriate that the cost involved in such training be paid fully by the individual and/or the employer rather than subsidized by the general public.

#### IV. ALTERNATIVES

The following alternatives were considered:

##### A. Status Quo

VCCS and DLI could recommend that public-supported training for boiler personnel in the Commonwealth is unnecessary and that the marketplace should continue to operate with current supply and demand.

Advantages:

1. No expense to the public or the occupation would be incurred.
2. Current low rate of boiler accidents due to operator error would be expected to continue.

Disadvantages:

1. The potential for harm due to boiler explosions could increase.
2. Short term, financial and productivity gains to employers and operators would not be realized.

B. Academic Certificate Program

DLI could recommend that public supported training for boiler operators in the Commonwealth is needed and VCCS could recommend the provision of training through an academic certificate program at all community college campuses system-wide.

Advantages:

1. The potential for an indeterminate decrease in accidents due to operator error would be possible.
2. Access to boiler training would be improved across the Commonwealth.
3. Employers would be given a basis upon which to consider potential employees.

Disadvantages:

1. Since training would be voluntary and not required to practice the occupation, enrollment levels (i.e. program utilization) would be difficult to estimate.
2. Program development, implementation, and operational costs would significantly impact college budgetary expenditures.
3. The benefit/cost of such a certificate program for the purpose of decreasing the average incidence of 1.8 accidents annually due to operator error is expected to be negative.
4. An additional cost to the operator (and to the employer as the consumer of services) would be inherent in this alternative. Not only would the cost of training be passed along to all employers, but the existence of a widely available formal certificate program could create a de facto protected title.

C. Specialized Training Courses

DLI could recommend that while statewide, public

supported training for boiler operators is not needed, there may be areas of the Commonwealth which could exhibit a demand for such training. VCCS could recommend that community colleges in such locations create specialized courses outside of a certificate program appropriate for the operation of boilers.

Advantages:

1. This approach provides an opportunity to quantify and address actual market need in areas expected to have sufficient demand.
2. Such a tailored program does not require the college to consider an expensive formal certificate program with significant start-up and overhead costs.
3. In comparison with the constraints of establishing or changing academic requirements needed by a certificate program, if market demand for such training were to change, the college could expand, downsize, or duplicate such a program of specialized courses relatively quickly and efficiently.

Disadvantage:

An additional cost to the operator (and the employer) would also be inherent in this alternative but to a lesser degree than if a formal certificate was utilized.

V. STATEMENT OF RECOMMENDATIONS

In consideration of the findings and conclusions presented herein, the DLI and the VCCS recommend that a statewide public-supported training program is not needed, however, there may exist areas in the Commonwealth which could exhibit a demand for such training given through specialized courses outside of a formal academic certificate program. Therefore, alternative "C" is recommended.

## GENERAL ASSEMBLY OF VIRGINIA -- 1989 SESSION

### HOUSE JOINT RESOLUTION NO. 371

*Requesting the Virginia Community College System and the Department of Labor and Industry to study jointly the need for a public-supported training program for boiler plant personnel in the Commonwealth.*

Agreed to by the House of Delegates, February 24, 1989

Agreed to by the Senate, February 23, 1989

WHEREAS, boilers and related systems are built for high temperature, high pressure, and high speed energy intensive processes; and

WHEREAS, boilers must be operated in a safe and controlled manner by qualified personnel around the clock; and

WHEREAS, risk management and facility-owner liability costs are proportional to proper, consistent and continuous performance of boiler plant staff; and

WHEREAS, the public safety, health, and welfare are at risk when exposed to substandard performance resulting in catastrophic, but avoidable, equipment or component failures; and

WHEREAS, with proper training boiler personnel can ensure the safe operations of these boilers and related systems; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Virginia Community College System and the Department of Labor and Industry are requested to study jointly the need for a public-supported training program for boiler plant personnel in the Commonwealth. If the agencies find that such a training program is needed, they shall determine how such a program shall be established.

The Virginia Community College System and the Department of Labor and Industry shall complete their work in time to submit jointly their findings and recommendations to the Governor and the 1990 Session of the General Assembly pursuant to the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

	NATIONAL INCIDENT OCCURRENCE						6 YEAR TOTAL							
	1983	1984	1985	1986	1987	1988								
<b>TOTAL ACTIVE OBJECTS REGISTERED</b>	14,961,271	15,557,989	16,234,910	16,974,281	17,744,416	18,466,764								
unit increase	N/A	598,718	676,921	739,351	770,155	722,348	† 3,505,493							
% annual change	N/A	4.0%	4.4%	4.6%	4.5%	4.1%	‡ 23.4%							
<b>POWER BOILER</b>														
Accidents	1137	1512	741	695	692	741	5518							
Injuries (as % of accidents)	39	3.4%	27	1.6%	40	5.4%	14	2.0%	59	0.8%	6	0.8%	185	3.4%
Deaths (as % of accidents)	6	0.5%	4	0.3%	13	1.8%	7	1.0%	10	1.4%	1	0.1%	41	0.7%
Operator error (as % of accidents)	221	19.4%	217	14.4%	143	19.3%	154	22.2%	79	11.4%	72	9.7%	688	16.1%
<b>STEAM &amp; H.W. HEATING BOILERS</b>														
Accidents	1051	1576	1554	952	641	645	6419							
Injuries (as % of accidents)	35	3.3%	30	1.9%	40	2.6%	140	14.7%	4	0.6%	24	3.7%	273	4.3%
Deaths (as % of accidents)	13	1.2%	5	0.3%	7	0.5%	49	5.1%	0	0.0%	6	0.9%	80	1.2%
Operator error (as % of accidents)	206	19.6%	109	6.9%	151	9.7%	212	22.3%	90	14.0%	88	13.6%	858	13.3%
<b>CAST IRON BOILERS</b>														
Accidents	1378	2088	1234	1213	1041	1122	8076							
Injuries (as % of accidents)	13	0.9%	22	0.4%	7	0.0%	6	0.5%	0	0.0%	10	0.9%	58	0.7%
Deaths (as % of accidents)	3	0.2%	8	0.4%	0	0.0%	2	0.2%	3	0.3%	1	0.1%	17	0.2%
Operator error (as % of accidents)	177	12.8%	278	13.2%	623	50.5%	92	7.6%	83	8.0%	73	6.5%	1324	16.4%
<b>PRESSURE VESSELS</b>														
Accidents	422	1310	477	458	283	322	3772							
Injuries (as % of accidents)	140	33.2%	437	5.6%	269	16.4%	99	21.6%	44	15.5%	59	18.3%	1048	32.0%
Deaths (as % of accidents)	17	4.0%	73	5.6%	78	16.4%	44	9.6%	5	1.8%	16	5.0%	233	7.1%
Operator error (as % of accidents)	137	32.5%	149	11.4%	84	17.6%	56	12.2%	37	13.1%	33	10.2%	496	15.2%
<b>ANNUAL TOTALS</b>														
Accidents	3988	6486	4006	3318	2657	2830	23285							
Accident rate per 100,000 objects	26.7	41.7	24.7	19.5	15.0	15.3								
Injuries (as % of accidents)	227	5.7%	516	8.0%	358	8.9%	259	7.8%	107	4.0%	99	3.5%	1584	6.7%
Deaths (as % of accidents)	39	1.0%	90	1.4%	98	2.4%	102	3.1%	18	0.7%	24	0.8%	371	1.6%
Operator error (as % of accidents)	741	18.6%	751	11.6%	1001	25.0%	514	15.5%	289	10.9%	268	9.4%	3562	15.3%

VIRGINIA INCIDENT OCCURRENCE

	1983	1984	1985	1986	1987	1988	6 YEAR TOTAL
<b>TOTAL ACTIVE OBJECTS REGISTERED</b>	55,789	58,802	60,893	64,245	67,854	71,690	
unit increase	N/A	2,813	2,261	3,392	3,609	3,836	+ 15,901
% annual change	N/A	5.0%	3.9%	5.6%	5.6%	5.7%	+ 28.5%
% of national total	0.373%	0.377%	0.375%	0.378%	0.382%	0.388%	+ 0.015%
<b>POWER BOILER</b>							
Accidents	3	0	4	5	3	4	19
Injuries (as % of accidents)	1 33.3%	0 0.0%	2 50.0%	0 0.0%	0 0.0%	1 25.0%	4 21.1%
Deaths (as % of accidents)	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Operator error (as % of accidents)	1 33.3%	0 0.0%	2 50.0%	1 20.0%	0 0.0%	1 25.0%	5 26.3%
<b>STEAM &amp; H. W. HEATING BOILERS</b>							
Accidents	5	6	4	3	5	3	26
Injuries (as % of accidents)	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Deaths (as % of accidents)	0 0.0%	0 0.0%	1 25.0%	2 66.7%	0 0.0%	0 0.0%	3 10.7%
Operator error (as % of accidents)	0 0.0%	0 0.0%	4 100.0%	0 0.0%	0 0.0%	0 0.0%	4 14.3%
<b>CAST IRON BOILERS</b>							
Accidents	4	0	2	1	5	2	14
Injuries (as % of accidents)	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Deaths (as % of accidents)	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Operator error (as % of accidents)	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
<b>PRESSURE VESSELS</b>							
Accidents	1	1	1	2	2	1	8
Injuries (as % of accidents)	0 0.0%	0 0.0%	0 0.0%	15 750.0%	1 50.0%	0 0.0%	16 200.0%
Deaths (as % of accidents)	1 100.0%	0 0.0%	0 0.0%	1 50.0%	0 0.0%	0 0.0%	2 25.0%
Operator error (as % of accidents)	0 0.0%	0 0.0%	1 100.0%	0 0.0%	0 0.0%	1 100.0%	2 25.0%
<b>ANNUAL TOTALS</b>							
Accidents	13	9	11	11	15	10	69
Accident rate per 100,000 objects	23.3	15.4	18.1	17.1	22.1	13.9	
Injuries (as % of accidents)	1 7.7%	0 0.0%	2 18.2%	23 209.1%	1 6.7%	1 10.0%	28 40.6%
Deaths (as % of accidents)	1 7.7%	0 0.0%	1 9.1%	3 27.3%	0 0.0%	0 0.0%	5 7.2%
Operator error (as % of accidents)	1 7.7%	0 0.0%	7 63.6%	1 9.1%	0 0.0%	2 20.0%	11 15.9%



	COMPARISON			IDENT OCCURANCE		
	1983 ACTUAL NATIONAL	VA. ESTIMATE BASED ON 1983 NATIONAL RATE	1983 ACTUAL VIRGINIA	1984 ACTUAL NATIONAL	VA. ESTIMATE BASED ON 1984 NATIONAL RATE	1984 ACTUAL VIRGINIA
TOTAL ACTIVE OBJECTS REGISTERED % annual change	14,961,271	55789	55789 0.373%	15,557,989	58,602	58,602 0.377%
<b>POWER BOILER</b>						
Accidents	1137	4	3	1512	6	0
Injuries	39	0	1	27	0	0
Deaths	6	0	0	4	0	0
Operator error	221	1	1	217	1	0
<b>STEAM &amp; H.W. HEATING BOILERS</b>						
Accidents	1051	4	5	1576	6	8
Injuries	35	0	0	30	0	0
Deaths	13	0	0	5	0	0
Operator error	206	1	0	109	0	0
<b>CAST IRON BOILERS</b>						
Accidents	1378	5	4	2088	8	0
Injuries	13	0	0	22	0	0
Deaths	3	0	0	8	0	0
Operator error	177	1	0	276	1	0
<b>PRESSURE VESSELS</b>						
Accidents	422	2	1	1310	5	1
Injuries	140	1	0	437	2	0
Deaths	17	0	1	73	0	0
Operator error	137	1	0	149	1	0
<b>ANNUAL TOTALS</b>						
Accidents	3988	15	13	6486	24	9
Injuries	227	1	1	516	2	0
Deaths	39	0	1	90	0	0
Operator error	741	3	1	751	3	0

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TOTAL ACTIVE OBJECTS REGISTERED % annual change	1985 ACTUAL NATIONAL	VA. ESTIMATE BASED ON 1985 NATIONAL RATE	1985 ACTUAL VIRGINIA	1986 ACTUAL NATIONAL	VA. ESTIMATE BASED ON 1986 NATIONAL RATE	1986 ACTUAL VIRGINIA
	16,234,910	60,863	60,862 0.375%	16,974,261	64245	64245 0.378%
<b>POWER BOILER</b>						
Accidents	741	3	4	695	3	5
Injuries	40	0	2	14	0	0
Deaths	13	0	0	7	0	0
Operator error	143	1	2	154	1	1
<b>STEAM &amp; H.W. HEATING BOILERS</b>						
Accidents	1554	6	4	952	4	3
Injuries	40	0	0	140	1	6
Deaths	7	0	1	49	0	2
Operator error	151	1	4	212	1	0
<b>CAST IRON BOILERS</b>						
Accidents	1234	5	2	1213	5	1
Injuries	7	0	0	6	0	0
Deaths	0	0	0	2	0	0
Operator error	623	2	0	92	0	0
<b>PRESSURE VESSELS</b>						
Accidents	477	2	1	458	2	2
Injuries	269	1	0	99	0	15
Deaths	76	0	0	44	0	1
Operator error	84	0	1	56	0	0
<b>ANNUAL TOTALS</b>						
Accidents	4006	15	11	3318	12	11
Injuries	358	1	2	259	1	23
Deaths	98	0	1	102	0	3
Operator error	1001	4	7	514	2	1

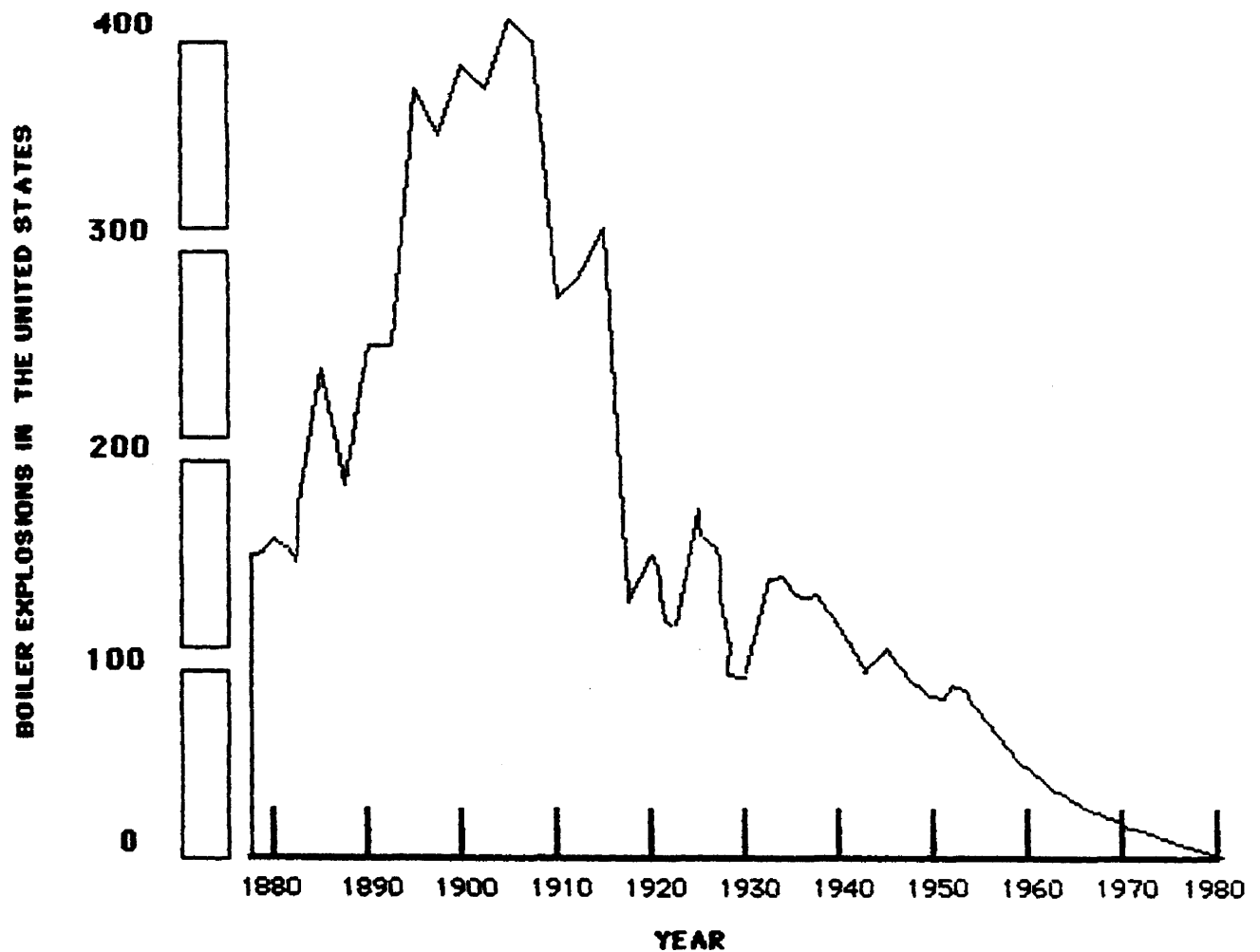
	ACTUAL NAT 1987	VA. ESTIMATE BASED ON 1987 NATIONAL RATE	ACTUAL VA 1987	ACTUAL NAT 1988	VA. ESTIMATE BASED ON 1988 NATIONAL RATE	ACTUAL VA 1988
TOTAL ACTIVE OBJECTS REGISTERED % annual change	17,744,418	67,854	67,854 0.382%	18,466,764	71,880	71,880 0.388%
<b>POWER BOILER</b>						
Accidents	692	3	3	741	3	4
Injuries	59	0	0	6	0	1
Deaths	10	0	0	1	0	0
Operator error	79	0	0	72	0	1
<b>STEAM &amp; H.W. HEATING BOILERS</b>						
Accidents	841	2	5	645	3	3
Injuries	4	0	0	24	0	0
Deaths	0	0	0	6	0	0
Operator error	90	0	0	88	0	0
<b>CAST IRON BOILERS</b>						
Accidents	1041	4	5	1122	4	2
Injuries	0	0	0	10	0	0
Deaths	3	0	0	1	0	0
Operator error	83	0	0	73	0	0
<b>PRESSURE VESSELS</b>						
Accidents	283	1	2	322	1	1
Injuries	44	0	1	59	0	0
Deaths	5	0	0	16	0	0
Operator error	37	0	0	33	0	1
<b>ANNUAL TOTALS</b>						
Accidents	2857	10	15	2830	11	10
Injuries	107	0	1	99	0	1
Deaths	18	0	0	24	0	0
Operator error	289	1	0	260	1	2

1983-1988 COMPARISON OF INCIDENT OCCURANCE  
NATIONAL / VIRGINIA

	VIRGINIA OCCURANCE ESTIMATE BASED ON NATIONAL RATE	ACTUAL VIRGINIA OCCURANCE				
<b>1983-1988 CUMULATIVE TOTALS</b>						
Accidents	88	69	69	69	69	72
Injuries	6	28	28	28	28	28
Deaths	1	5	5	5	5	5
Operator error	13	11	10	12	13	11
Operator error as a percentage of total accidents	15.25%	15.94%	14.49%	17.39%	18.84%	15.28%

**HISTORICAL INCIDENCE OF BOILER EXPLOSIONS IN THE UNITED STATES: 1880 - 1980**

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Source: "National Board Celebrates Sixty Years of Progress", National Board Bulletin, National Board of Boiler and Pressure Vessel Inspectors. V. 37 No. 2, October 1979, p. 3

