RENSSELAER POLYTECHNIC INSTITUTE
REACTOR CRITICAL FACILITY

LICENSE: CX-22
DOCKET: 50-225

RELICENSING REPORT

REDACTED VERSION

SECURITY RELATED INFORMATION REMOVED

Redacted text and figures have been blacked out

Rensselaer Polytechnic Institute
Reactor Critical Facility
Relicensing Report

[redacted]

Jonathan E. Stephens, SRO
Timothy H. Trumbull, Supervisor

December 2002

Rensselaer

Table of Contents

RENSSELAER POLYTECHNIC INSTITUTE
REACTOR CRITICAL FACILITY
SAFETY ANALYSIS REPORT

License No. CX-22
Docket No. 50-225

Jonathan E. Stephens
November 2002

Table of Contents

1. THE FACILITY

1.1 Introduction

This document is prepared as part of the application for renewal of License CX-22.

Rensselaer Polytechnic Institute owns and operates a zero-power university research reactor at the Reactor Critical Facility (RCF), located on the south bank of the Mohawk River in Schenectady, New York. Reactor power rarely exceeds 1 watt; consequently, safety concerns are minimal and no radioactive waste is generated at the facility. [redacted]

This Safety Analysis Report has been structured in accordance with NUREG 1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors", dated February 1996. This document contains numerous updates from the last SAR for the RCF, submitted in June 1986 as part of the facility conversion from HEU to LEU fuel.

1.2 Summary and Conclusions on Principal Safety Considerations

Due to the low power levels (typically < 1 watt) during reactor operation, reactor cooling is not an issue at the RCF, even in the case of the design basis accident scenario described in Chapter 13. Fission product inventories are also minimal. The worst case accident scenario for the fuel vault involves complete flooding of the vault, which results in an infinite multiplication factor below 0.9.

1.3 General Description of Facility

The RCF is located on Erie Blvd. in Schenectady, New York, approximately 35 minutes from the main RPI campus in Troy. The facility (Figure 1.1) consists of the high bay, which contains the reactor and fuel vault (Figure 1.2); control room (Figure 1.3), equipment hallway, office, lavatory and counting room. Substantial equipment upgrades are in progress in the control room. [redacted]

The reactor room is [redacted]

A stack extends above the reactor room to 50 feet above ground level. It contains a CWS filter for removing the small amount of fission products that might evolve from a maximum credible accident. [redacted]

[redacted]

An [redacted] A storage rack constructed of unistrut is mounted against one wall of the vault opposite the vault access door. Figure 1.2 displays the storage arrangement. [redacted] The vault can safely accommodate, in physical weight and reactivity, the total inventory of fuel pins. The fuel storage vault was originally designed to safely store HEU fuel plates (the original fuel type for the reactor) with 81 kg of ^{235}U. Conservative calculations of the infinite multiplication factor for the vault, when housing both the old HEU and new LEU fuel under completely flooded conditions, yield a value of much less than 0.90.

[redacted]

Major features of the control room are the instrument cable trench, an enclosed sight glass indicating reactor tank water level, the control console (CP1), and the auxiliary electric panel (CP2). Figure 1.3 shows the primary control panel (CP1) in the control room.

[redacted]

The additional shielding constructed for the counting room has already been described. This room contains the scintillation counting equipment, an oscilloscope, a multi-channel analyzer, and a facility computer system.

1.4 Shared Facilities and Equipment

The Reactor Critical Facility is a stand-alone laboratory. There are no shared facilities or equipment.

1.5 Comparison with Similar Facilities

The RCF is unlike any other reactor facility, including other university research reactors. This is considered to be one of the greatest advantages of the RCF. Since the reactor operates at lower power levels than other university reactors, safety concerns are generally much less than those that exist at other facilities.

1.6 Summary of Operations

The reactor has been, and/or will continue to be used for the following experiments:

- Radiation surveys
- Critical rod position measurements
- Control rod worth measurements
- Calibration of reactor instrumentation
- Subcritical multiplication measurements
- Reactor period measurements
- Measurement of temperature, void, and boron coefficients of reactivity
- Delayed gamma measurements
- Absolute power measurements via gold foil activation
- Relative flux shape measurements
- Fuel pin worth measurements
- Critical benchmark experiments

The above list includes experiments used for classes and graduate theses, and is not exclusive.

1.7 Compliance with the Nuclear Waste Policy Act of 1982

Section 302(b)(1)(B) of the Nuclear Waste Policy Act of 1982 provides that the NRC may require, as a precondition to issuing or renewing an operating license for a research or test reactor, that the applicant shall have entered into an agreement with the Department of Energy (DOE) for the disposal of high-level radioactive waste and spent nuclear fuel. By letter dated May 3, 1983, DOE (R.L. Morgan) informed the NRC (H. Denton) that it has entered into contracts with universities and other government agencies operating non-power reactors to provide that DOE retain title to the fuel. Moreover, DOE is obligated to take the spent fuel and/or high-level waste for storage or reprocessing.

Because RPI has entered into such a contract with DOE, the applicable requirements of the Waste Policy Act of 1982 have been satisfied. It should be noted that until the RCF is decommissioned, the facility will produce neither high-level waste nor spent fuel.

1.8 Facility Modifications and History

Construction of the Reactor Critical Facility (RCF) was completed in July of 1956 by ALCO Products, Inc. Originally, the facility was constructed as a laboratory in which reactor experiments, necessary for the design and development of military and commercial power plants, could be performed in a safe and efficient manner. The experiments performed here were "zero-power" experiments, all of which took place at very low power levels. In 1964, Rensselaer Polytechnic Institute (RPI) assumed operation of the facility for the instruction of students in the Institute's Department of Nuclear Engineering and Science, and for research and testing purposes.

Originally, the reactor utilized highly enriched uranium (HEU) fuel. In the mid 80's, the Nuclear Regulatory Commission (NRC) mandated that all NRC-licensed non-power reactors using highly enriched uranium (HEU) convert to low enriched uranium (LEU) fuel, unless compelling reasons can be given for continued use of HEU. The rule was set down to address an increasing concern with the possibility that HEU, widely used in non-power reactors around the world, might be diverted from its intended peaceful uses. Thus RPI refueled the core with LEU as part of a reactor upgrade supported by the U.S. Department of Energy (DOE) and by RPI. A Safety Analysis Report was submitted in June 1986 regarding this modification.

2. FACILITY DESCRIPTION

2.1 Geography and Demography

2.1.1 Site Location and Description

2.1.1.1 Specification and Location

The RPI Reactor Critical Facility (RCF) is situated on the south bank of the Mohawk River in the city of Schenectady, NY (Figure 2.1). The facility is located at [redacted] On the USGS Schenectady, NY quad, the [redacted] The geographic orientation of the RCF is best viewed in Figure 2.2. Exclusion areas depicted in Figure 2.2 are divided into two zones. The inner zone is enclosed by a chain linked fence with two controlled access gates. It is roughly a [redacted] with a minimum distance [redacted] The civil exclusion zone encompasses the access road to the RCF from Erie Blvd. and the facility parking lot; [redacted] The civil exclusion zone is bordered by the perimeter of the former ALCO property shown in Figure 2.2. The civil exclusion zone is open to the river on the northwest side.

The city of Schenectady is geographically situated in the eastern section of Schenectady County, which has an area of 209 square miles. The Schenectady area is more generally considered to be the western boundary of a larger metropolitan area, the Capital Region, composed chiefly of the cities of Albany, Troy and Schenectady. The center of this area is in the vicinity of the Albany Airport, which is about 7 miles to the southeast of the facility. The RCF is one mile north-northeast of the commercial center of Schenectady and about 3 miles downstream from the public water supply.

2.1.1.2 Boundary and Zone Area Maps

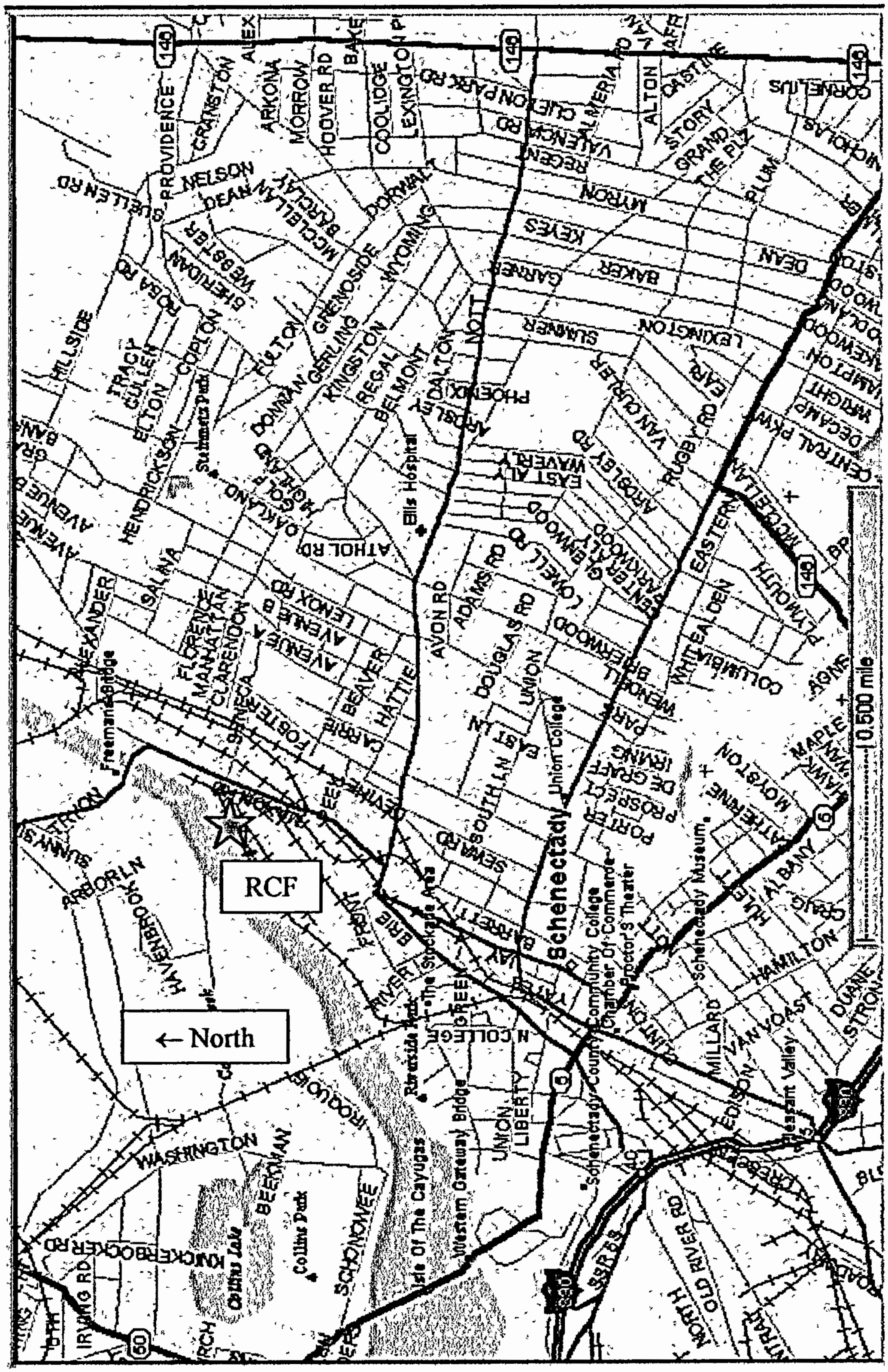


Figure 2.1: Schenectady, NY

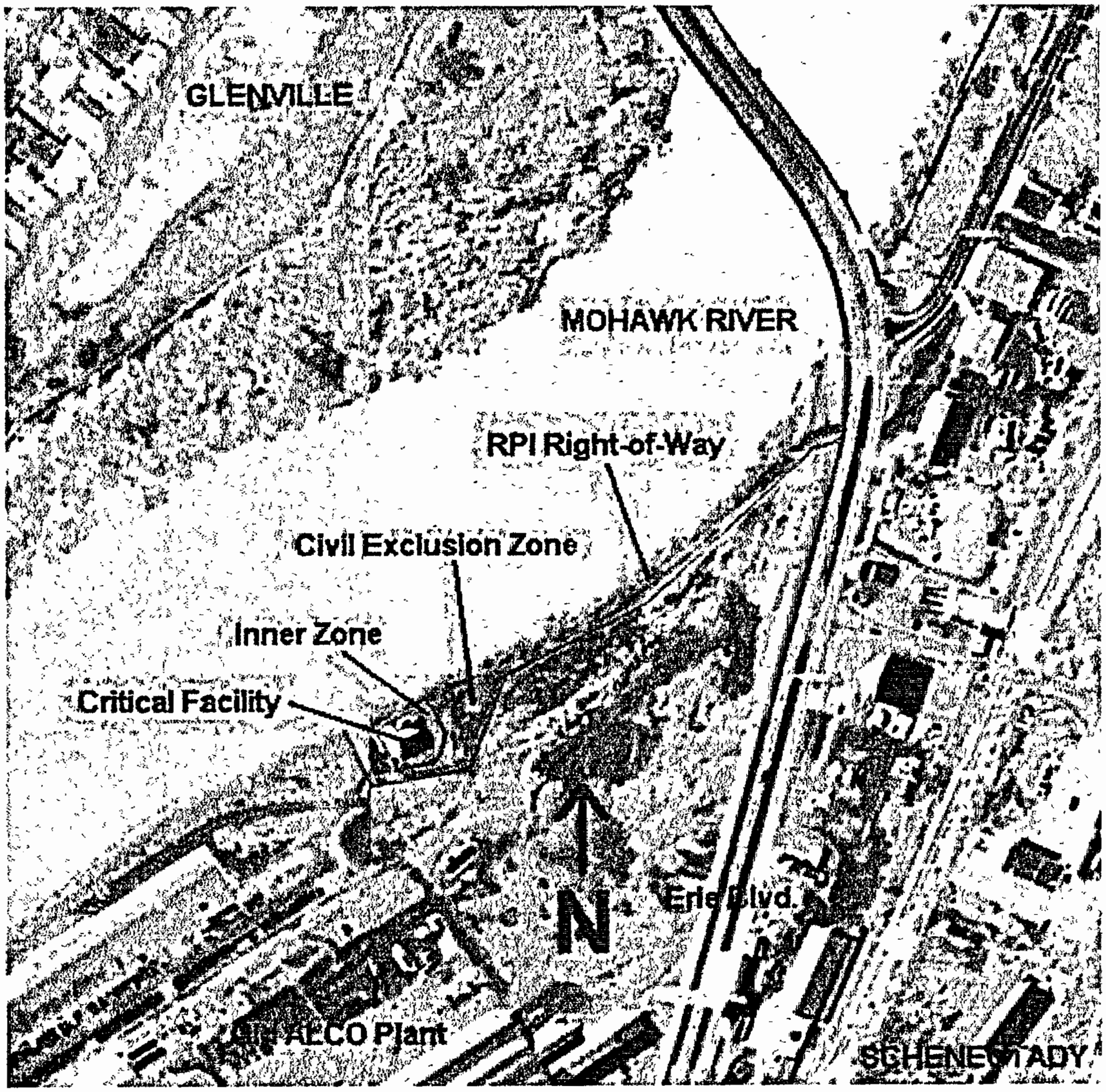


Figure 2.2: Site and Vicinity

2.1.2 Population Distribution

According to the 2000 US Census, the population of Schenectady County is approximately 146,000. The nearest commercial establishment to the facility is 700 feet distant. The nearest residence is 1150 feet to the southeast. Selected population statistics may be found on the following pages.

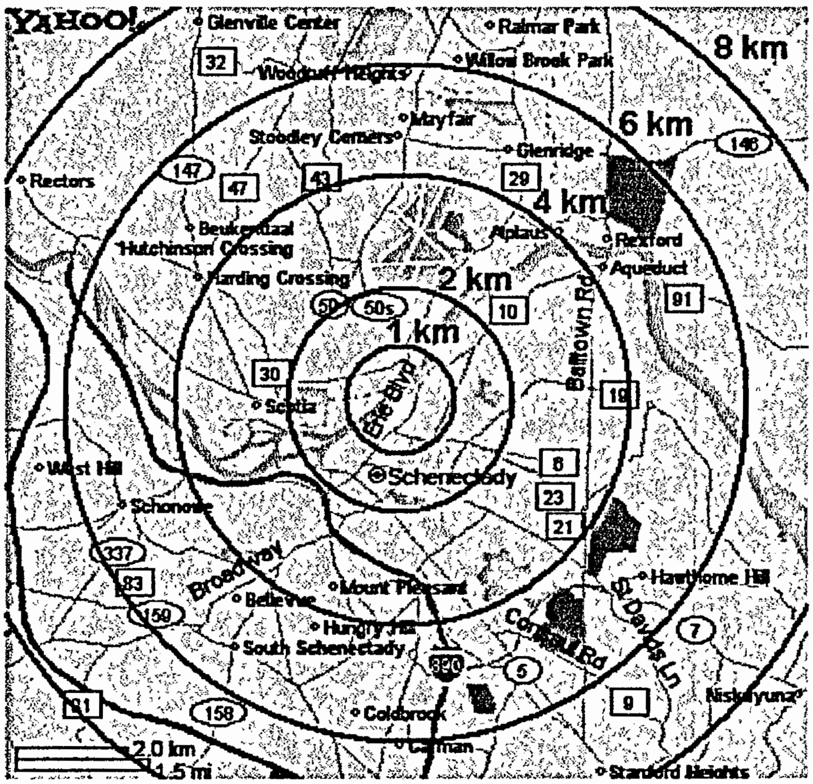


Figure 2.3: City of Schenectady, New York

Profile of Selected Social Characteristics: 1990 & 2000 [redacted]

Profile of Selected Social Characteristics	Town of Waterford		Village of Waterford		Town of Wilton		Schenectady County		Town of Duanesburg	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
SCHOOL ENROLLMENT										
Population 3 & Over Enrolled in School	2,084	2,038	630	517	2,860	3,349	35,063	37,662	1,507	1,483
Nursery School, Preschool		133		36		207		2,410		33
Kindergarten		83		44		270		2,145		52
Elementary School (1-8)		1,045		273		1,556		17,071		804
High School (9-12)		454		110		871		7,655		404
College or Graduate School	593	323	130	54	423	445	9,912	8,381	290	190
EDUCATIONAL ATTAINMENT										
Population 25 & Over	5,788	5,821	1,638	1,457	6,558	8,116	100,422	99,568	3,521	3,930
Less Than 9th Grade	355	293	126	70	720	253	6,429	4,150	89	110
9th to 12th Grade, No Diploma	812	709	250	172	733	488	12,931	10,985	468	280
High School Graduate (includes Equivalency)	2,060	1,917	592	578	1,980	2,530	33,425	30,812	1,348	1,272
Some College, No Degree	1,210	1,205	324	275	1,151	1,347	15,630	17,608	665	696
Associate Degree	604	595	161	156	532	795	8,951	9,795	321	626
Bachelor Degree	472	699	118	148	721	1,566	13,270	14,506	373	518
Graduate or Professional Degree	275	403	67	58	721	1,137	9,786	11,712	257	428
Percent High School Graduate or Higher	79 8%	82.8%	77.0%	83 4%	77 8%	90 9%	80 7%	84 8%	84 2%	90 1%
Percent Bachelor Degree or Higher	12 9%	18 9%	11.3%	14.1%	22 0%	33 3%	23 0%	26.3%	17.9%	24 1%
MARITAL STATUS										
Population 15 & Over		6,807		1,761		9,513		116,618		4,522
Never Married	1,739	1,813	509	536	2,023	2,015	32,322	31,007	872	822
Now Married (Except Separated)	4,023	3,715	959	835	4,903	6,051	65,041	61,750	2,777	3,146
Separated	186	269	66	74	200	137	3,362	3,481	92	90
Widowed	540	439	205	134	307	455	10,991	9,907	205	193
Female	424	367	170	114	252	350	9,111	8,028	162	129
Divorced	407	571	136	182	485	855	8,710	10,473	218	271
Female	266	345	89	113	275	459	5,264	6,232	112	131
GRANDPARENTS AS CAREGIVERS										
Grandparent Living with 1 or More of Own Grandchildren Under 18		49		17		183		1,846		112
Grandparent Responsible for Grandchildren		9		0		108		726		35
VETERAN STATUS										
Civilian Population 18 & Over	6,806	6,501	1,912	1,684	7,644	8,819	118,504	110,842	4,087	4,245
Civilian Veterans	1,222	983	372	234	1,232	1,379	18,035	15,111	741	527
DISABILITY STATUS OF NONINSTITUTIONAL CIVIL. POP.										
Population 5 to 20		1,767		484		3,092		31,723		1,407
With a Disability		186		59		242		2,740		74
Population 21 to 64		5,013		1,264		7,474		80,796		3,540
With a Disability		629		181		1,099		14,927		403
Percent Employed		57.2%		58.6%		53 5%		56 3%		66 0%
No Disability		4,384		1,083		6,375		65,869		3,137
Percent Employed		84 1%		82 9%		81.3%		80.2%		83.7%
Population 65 & Over	1,137	1,212	464	328	760	982	23,802	22,792	483	532
With a Disability	149	329	84	97	118	467	4,462	8,146	68	119
RESIDENCE IN 1995										
Population 5 Years & Over	8,033	8,009	2,323	2,093	9,773	11,602	138,885	137,584	5,040	5,483
Same House Five Years Ago	4,547	5,009	1,434	1,324	4,732	6,978	83,152	84,091	3,092	4,118
Different House in the U S Five Years Ago	3,464	2,975	889	760	5,002	4,574	54,517	51,374	1,920	1,344
Same County	1,324	1,520	606	308	2,560	2,712	30,767	31,299	886	731
Different County	2,140	1,455	283	452	2,442	1,862	23,750	20,075	1,034	613
Same State	1,818	1,255	238	398	1,369	804	17,190	14,662	771	467
Different State	322	200	45	54	1,073	1,058	6,560	5,413	263	146
Elsewhere in 1995	22	25	0	9	39	50	1,216	2,119	28	21
NATIVITY & PLACE OF BIRTH										
Total Population	8,695	8,515	2,492	2,204	10,623	12,511	149,285	146,555	5,474	5,808
Native	8,433	8,326	2,461	2,150	10,402	12,150	141,853	138,744	5,332	5,696
Born in United States	8,398	8,279	2,450	2,131	10,339	12,013	140,435	137,087	5,298	5,655
State of Residence	7,553	7,415	2,356	2,004	7,874	9,611	118,793	117,031	4,676	4,794
Different State	845	864	94	127	2,465	2,402	21,642	20,056	622	861
Born Outside United States	35	47	11	19	63	137	1,418	1,657	34	41
Foreign Born	262	189	31	54	221	361	7,432	7,811	142	112
Entered 1990 to March 2000	86	19	0	19	36	69	1,463	2,450	6	15
Naturalized Citizen	167	145	31	33	159	278	5,395	4,932	102	57
Not a Citizen	95	44	0	21	62	83	2,037	2,879	40	55

[redacted]

Profile of Selected Social Characteristics: 1990 & 2000

Profile of Selected Social Characteristics	Town of Waterford		Village of Waterford		Town of Wilton		Schenectady County		Town of Duanesburg	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
REGION OF BIRTH OF FOREIGN BORN										
Total (excluding Born at Sea)	262	189	(X)	54	214	361	7,241	7,811	141	112
Europe	174	83	(X)	21	117	150	4,574	3,648	94	92
Asia	22	17	(X)	17	30	117	1,637	2,237	19	0
Africa	7	8	(X)	0	14	0	119	275	0	0
Oceania	10	0	(X)	0	0	0	38	32	0	0
Latin America	0	22	(X)	16	20	51	591	1,305	12	20
North America	49	59	(X)	0	33	43	407	314	16	0
LANGUAGE SPOKEN AT HOME										
Population 5 & Older	8,033	8,009	(X)	2,093	9,773	11,602	138,885	137,584	5,040	5,483
English Only	7,607	7,548	(X)	1,979	9,394	11,096	126,666	123,984	4,953	5,226
Language Other Than English	426	461	(X)	114	379	506	12,219	13,600	87	257
Speak English Less Than "Very Well"	187	124	(X)	48	201	79	5,262	4,258	24	54
Spanish	29	129	(X)	34	103	158	1,945	3,756	13	113
Speak English Less Than "Very Well"	8	24	(X)	3	43	24	588	1,123	7	9
Other Indo-European Languages	391	317	(X)	65	234	306	8,860	7,660	74	117
Speak English Less Than "Very Well"	138	91	(X)	36	96	45	2,744	2,304	17	29
Asian & Pacific Island Languages	6	6	(X)	6	13	32	1,089	1,425	0	3
Speak English Less Than "Very Well"	6	0	(X)	0	7	10	388	519	0	2
ANCESTRY (Single or Multiple)										
Total Population	8,695	8,515	2,492	2,204	10,623	12,511	149,285	146,555	5,474	5,808
Total Ancestries Reported	12,231	11,052	3,651	2,730	14,434	16,093	205,651	178,110	8,107	7,256
Arab	42	19	0	0	48	8	337	596	18	0
Czech (1)	21	37	0	5	62	64	771	1,120	48	29
Danish	62	86	19	21	46	52	654	627	15	6
Dutch	300	378	111	138	580	425	8,296	6,075	583	358
English	1,297	867	381	172	1,660	1,830	21,265	15,206	1,170	941
French (except Basque) (1)	2,000	1,621	586	438	1,338	1,477	13,081	9,996	465	536
French Canadian (1)	527	566	124	108	412	423	3,834	3,021	152	132
German	1,327	1,381	398	291	2,330	1,939	32,657	22,897	1,739	1,224
Greek	12	32	5	0	110	26	833	687	18	20
Hungarian	36	16	5	0	50	91	1,101	1,247	28	86
Irish (1)	2,457	2,426	876	599	2,818	2,997	31,862	27,276	1,286	1,099
Italian	1,748	1,717	684	480	1,240	1,844	34,246	32,270	744	981
Lithuanian	19	47	0	0	24	84	1,142	835	15	7
Norwegian	43	55	0	21	19	110	940	723	12	58
Polish	1,014	604	270	109	825	889	17,683	14,616	467	371
Portuguese	17	24	0	7	14	18	191	164	0	8
Russian	131	47	5	7	78	286	2,343	1,797	7	43
Scotch-Irish	75	94	37	38	213	143	2,124	1,895	131	81
Scottish	283	140	67	31	366	354	3,950	3,452	171	210
Slovak	30	11	8	0	91	108	1,710	469	117	0
Subsaharan African	0	20	0	0	0	0	192	804	0	0
Swedish	61	46	0	7	124	150	1,844	1,467	34	41
Swiss	9	0	0	0	29	21	555	420	35	33
Ukrainian	134	163	11	29	84	70	961	708	33	0
United States or American	134	75	31	50	497	1,028	3,107	4,696	295	292
Welsh	21	24	5	4	123	188	1,181	978	85	136
West Indian (excluding Hispanic Groups)	0	6	0	0	0	46	321	549	0	0
Other Ancestries	431	550	28	175	1,253	1,422	18,470	23,519	439	564

(X) Not Applicable

(1) The data represent a combination of two ancestries shown separately in Summary File 3.
Czech includes Czechoslovakian. French includes Alsatian.
French Canadian includes Acadian/Cajun Irish includes Celtic

Note: Data for Towns with Villages include the Village data

Profile of Selected Social Characteristics: 1990 & 2000

[redacted]

Profile of Selected Social Characteristics	Village of Delanson		Town of Glenville		Village of Scotia		Town of Niskayuna		Town of Princetown	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
SCHOOL ENROLLMENT										
Population 3 & Over Enrolled in School	95	103	6,814	6,646	1,781	2,100	4,913	5,474	485	582
Nursery School, Preschool		3		431		120		409		22
Kindergarten		2		449		136		307		25
Elementary School (1-8)		44		3,042		1,029		2,523		258
High School (9-12)		31		1,700		489		1,247		180
College or Graduate School	19	23	1,644	1,024	410	326	1,147	988	67	97
EDUCATIONAL ATTAINMENT										
Population 25 & Over	232	268	19,927	20,120	4,934	5,402	13,140	14,134	1,334	1,463
Less Than 9th Grade	3	3	700	525	170	139	625	393	56	34
9th to 12th Grade, No Diploma	26	18	1,761	1,467	426	537	706	657	167	128
High School Graduate (includes Equivalency)	85	121	6,343	5,724	1,745	1,670	2,394	2,090	511	512
Some College, No Degree	41	43	3,491	3,769	887	1,109	1,759	2,016	233	252
Associate Degree	20	13	2,035	2,279	574	638	1,152	1,228	171	187
Bachelor Degree	46	38	3,144	3,545	637	753	3,241	3,628	109	192
Graduate or Professional Degree	11	32	2,453	2,811	495	556	3,263	4,122	87	158
Percent High School Graduate or Higher	87.5%	92.2%	87.6%	90.1%	87.9%	87.5%	89.9%	92.6%	83.3%	88.9%
Percent Bachelor Degree or Higher	24.6%	26.1%	28.1%	31.6%	22.9%	24.2%	49.5%	54.8%	14.7%	23.9%
MARITAL STATUS										
Population 15 & Over		320		22,765		6,234		15,891		1,723
Never Married	54	60	4,846	4,411	1,317	1,467	3,347	3,082	351	392
Now Married (Except Separated)	165	212	14,327	14,217	3,180	3,311	9,680	10,460	1,051	1,085
Separated	5	7	432	359	151	188	269	303	28	20
Widowed	29	17	2,211	2,068	625	643	1,038	990	70	92
Female	20	9	1,820	1,666	526	558	865	815	58	76
Divorced	11	24	1,337	1,710	511	625	782	1,056	77	134
Female	4	10	820	1,085	346	449	496	694	40	61
GRANDPARENTS AS CAREGIVERS										
Grandparent Living with 1 or More of Own Grandchildren Under 18		5		225		41		192		18
Grandparent Responsible for Grandchildren		3		84		10		45		0
VETERAN STATUS										
Civilian Population 18 & Over	270	291	22,727	21,475	5,678	5,865	14,782	14,973	1,532	1,589
Civilian Veterans	38	50	3,744	3,225	909	761	2,012	1,917	255	202
DISABILITY STATUS OF NONINSTITUTIONAL CIVIL. POP.										
Population 5 to 20		93		5,801		1,820		4,452		526
With a Disability		9		360		137		227		28
Population 21 to 64		224		15,320		4,296		11,040		1,272
With a Disability		36		1,967		572		1,183		166
Percent Employed		83.3%		59.8%		64.0%		57.7%		59.6%
No Disability		188		13,353		3,724		9,857		1,106
Percent Employed		87.8%		82.9%		82.4%		81.2%		80.9%
Population 65 & Over	37	49	4,871	4,776	1,140	1,046	2,785	3,289	218	248
With a Disability	6	9	716	1,493	235	398	415	955	37	107
RESIDENCE IN 1995										
Population 5 Years & Over	324	370	27,005	26,635	6,795	7,460	17,806	19,034	1,889	2,046
Same House Five Years Ago	227	255	18,174	18,428	4,277	4,481	10,830	12,863	1,317	1,579
Different House in the U S Five Years Ago	97	115	8,733	7,974	2,478	2,877	6,677	5,759	567	462
Same County	55	63	5,474	5,059	1,641	1,996	2,995	2,707	396	283
Different County	42	52	3,259	2,915	837	881	3,682	3,052	171	179
Same State	42	34	2,164	1,993	492	603	2,544	2,213	123	109
Different State	0	18	1,095	922	345	278	1,138	839	48	70
Elsewhere in 1995	0	0	98	233	40	102	299	412	5	5
NATIVITY & PLACE OF BIRTH										
Total Population	361	390	28,771	28,061	7,359	7,957	19,048	20,259	2,031	2,132
Native	356	379	27,731	27,244	7,171	7,776	17,759	18,369	1,977	2,085
Born in United States	354	371	27,492	27,101	7,100	7,752	17,495	18,278	1,972	2,080
State of Residence	313	320	22,672	22,989	6,144	6,962	13,102	14,132	1,750	1,844
Different State	41	51	4,820	4,112	956	790	4,393	4,146	222	236
Born Outside United States	2	8	239	143	71	24	264	91	5	5
Foreign Born	5	11	1,040	817	188	181	1,289	1,890	54	47
Entered 1990 to March 2000	0	0	137	110	58	42	226	609	2	0
Naturalized Citizen	2	5	808	600	107	88	993	1,269	40	36
Not a Citizen	3	6	232	217	81	93	296	621	14	11

Profile of Selected Social Characteristics: 1990 & 2000

[redacted]

Profile of Selected Social Characteristics	Village of Delanson		Town of Glenville		Village of Scotia		Town of Niskayuna		Town of Princetown	
	1990	2000	1990	2000	1990	2000	1990	2000	1990	2000
REGION OF BIRTH OF FOREIGN BORN										
Total (excluding Born at Sea)	(X)	11	1,002	817	188	181	1,267	1,890	(X)	47
Europe	(X)	9	697	417	77	55	614	808	(X)	26
Asia	(X)	0	162	178	69	73	552	979	(X)	4
Africa	(X)	0	23	0	0	0	7	20	(X)	0
Oceania	(X)	0	8	7	0	0	20	0	(X)	0
Latin America	(X)	2	65	123	20	25	54	57	(X)	7
North America	(X)	0	51	92	26	28	45	26	(X)	10
LANGUAGE SPOKEN AT HOME										
Population 5 & Older	(X)	370	27,005	26,635	6,795	7,460	17,806	19,034	(X)	2,046
English Only	(X)	357	25,478	24,924	6,485	6,991	16,204	16,825	(X)	1,950
Language Other Than English	(X)	13	1,527	1,711	310	469	1,602	2,209	(X)	96
Speak English Less Than "Very Well"	(X)	5	527	338	74	82	412	601	(X)	32
Spanish	(X)	3	151	331	23	130	264	267	(X)	40
Speak English Less Than "Very Well"	(X)	1	24	73	10	9	65	68	(X)	19
Other Indo-European Languages	(X)	7	1,191	1,232	225	285	816	1,089	(X)	56
Speak English Less Than "Very Well"	(X)	2	337	233	34	48	108	252	(X)	13
Asian & Pacific Island Languages	(X)	3	156	94	62	54	480	684	(X)	0
Speak English Less Than "Very Well"	(X)	2	43	32	17	25	141	199	(X)	0
ANCESTRY (Single or Multiple)										
Total Population	361	390	28,771	28,061	7,359	7,957	19,048	20,259	2,031	2,132
Total Ancestries Reported	522	425	41,157	36,536	11,103	10,789	25,911	24,782	3,030	2,697
Arab	0	0	25	42	6	0	25	172	0	2
Czech (1)	5	0	138	513	57	169	132	97	9	17
Danish	0	0	174	247	50	53	103	78	13	17
Dutch	20	33	1,743	1,412	434	460	762	513	204	184
English	82	51	5,554	4,127	1,446	1,128	3,284	2,493	396	289
French (except Basque) (1)	14	30	2,522	2,277	777	882	1,041	854	259	201
French Canadian (1)	7	1	711	671	313	283	480	417	68	35
German	106	75	7,418	5,752	2,055	1,516	4,257	3,075	603	413
Greek	0	0	188	153	16	69	131	118	0	0
Hungarian	14	2	125	234	28	55	225	325	20	12
Irish (1)	125	57	6,179	5,877	1,758	1,850	3,981	4,269	459	382
Italian	62	35	5,296	5,286	1,423	1,508	3,519	3,985	433	486
Lithuanian	0	0	297	265	61	46	132	114	7	21
Norwegian	0	0	306	246	85	59	187	165	13	13
Polish	31	31	4,075	2,860	962	849	1,955	1,873	207	193
Portuguese	0	0	40	56	0	0	0	12	0	0
Russian	0	16	323	237	80	105	727	669	13	5
Scotch-Irish	7	12	592	707	147	157	306	244	56	35
Scottish	12	8	1,163	1,050	246	250	514	557	47	68
Slovak	5	0	392	143	99	53	175	42	19	18
Subsaharan African	0	0	25	24	0	24	0	7	0	0
Swedish	7	8	438	420	152	85	315	332	27	23
Swiss	4	0	116	129	0	48	102	101	11	4
Ukrainian	0	0	215	151	56	8	169	159	9	4
United States or American	7	31	516	988	130	246	422	767	52	100
Welsh	0	0	316	285	95	49	214	119	18	17
West Indian (excluding Hispanic Groups)	0	0	42	16	6	0	30	11	0	2
Other Ancestries	14	35	2,228	2,368	621	837	2,723	3,214	87	156

(X): Not Applicable

(1): The data represent a combination of two ancestries shown separately in Summary File 3.
Czech includes Czechoslovakian. French includes Alsatian.
French Canadian includes Acadian/Cajun Irish includes Celtic

Note: Data for Towns with Villages include the Village data

Profile of Selected Social Characteristics: 1990 & 2000

[redacted]

Profile of Selected Social Characteristics	Town of Rotterdam		City of Schenectady		Capital District		New York State	
	1990	2000	1990	2000	1990	2000	1990	2000
SCHOOL ENROLLMENT								
Population 3 & Over Enrolled in School	6,213	6,813	15,131	16,664	200,683	215,301	4,656,218	5,217,030
Nursery School, Preschool		462		1,053		13,556		331,376
Kindergarten		481		831		10,834		272,504
Elementary School (1-8)		3,206		7,238		89,523		2,208,497
High School (9-12)		1,382		2,742		42,286		1,103,278
College or Graduate School	1,620	1,282	5,144	4,800	66,291	59,102	1,439,199	1,301,375
EDUCATIONAL ATTAINMENT								
Population 25 & Over	19,861	20,159	42,639	39,762	505,149	530,197	11,818,569	12,542,536
Less Than 9th Grade	1,308	603	3,651	2,485	35,818	21,207	1,200,827	1,005,805
9th to 12th Grade, No Diploma	2,718	2,120	7,111	6,333	61,543	51,706	1,776,777	1,620,519
High School Graduate (includes Equivalency)	8,195	8,273	14,634	12,941	158,197	155,265	3,485,686	3,480,768
Some College, No Degree	3,010	3,797	6,472	7,078	78,306	92,358	1,851,182	2,103,404
Associate Degree	1,887	2,102	3,385	3,373	45,746	52,886	770,268	898,828
Bachelor Degree	1,755	2,163	4,648	4,460	71,350	87,006	1,561,719	1,954,242
Graduate or Professional Degree	988	1,101	2,738	3,092	54,189	69,769	1,172,110	1,478,970
Percent High School Graduate or Higher	79.7%	86.5%	74.8%	77.8%	80.7%	86.2%	74.8%	79.1%
Percent Bachelor Degree or Higher	13.8%	16.2%	17.3%	19.0%	24.9%	29.6%	23.1%	27.4%
MARITAL STATUS								
Population 15 & Over		22,829		48,888		637,017		15,055,876
Never Married	5,173	4,930	17,733	17,370	189,353	182,313	4,632,260	4,777,896
Now Married (Except Separated)	14,397	13,346	22,809	19,496	328,069	336,548	7,189,078	7,535,841
Separated	429	536	2,112	2,173	17,241	17,353	490,366	484,640
Widowed	2,015	2,057	5,452	4,507	49,768	46,695	1,167,111	1,084,409
Female	1,671	1,638	4,535	3,704	41,409	37,589	967,501	887,299
Divorced	1,376	1,960	4,920	5,342	41,618	54,108	937,693	1,173,090
Female	839	1,111	2,957	3,150	24,667	31,343	577,013	709,220
GRANDPARENTS AS CAREGIVERS								
Grandparent Living with 1 or More of Own Grandchildren Under 18		476		823		9,349		412,000
Grandparent Responsible for Grandchildren		186		376		3,502		143,014
VETERAN STATUS								
Civilian Population 18 & Over	22,969	21,769	52,407	46,791	614,369	603,843	14,151,119	14,278,716
Civilian Veterans	3,953	3,385	7,330	5,855	90,446	79,290	1,707,476	1,361,164
DISABILITY STATUS OF NONINSTITUTIONAL CIVIL. POP.								
Population 5 to 20		5,706		13,831		175,501		4,197,977
With a Disability		424		1,627		14,866		370,856
Population 21 to 64		15,666		33,958		454,675		10,932,732
With a Disability		2,291		8,917		74,993		2,294,611
Percent Employed		59.2%		54.1%		58.7%		54.1%
No Disability		13,375		25,041		379,682		8,638,121
Percent Employed		80.9%		77.4%		81.3%		74.1%
Population 65 & Over	4,790	5,289	10,655	8,658	101,040	103,964	2,239,166	2,333,555
With a Disability	701	1,853	2,525	3,619	18,623	37,624	469,194	940,680
RESIDENCE IN 1995								
Population 5 Years & Over	26,737	26,762	60,408	57,624	724,438	746,408	16,743,048	17,749,110
Same House Five Years Ago	18,991	18,659	30,748	28,444	411,411	441,449	10,385,913	10,961,493
Different House in the U.S. Five Years Ago	7,697	8,010	28,923	27,825	306,170	294,176	5,743,411	6,066,869
Same County	5,144	5,552	15,872	16,967	160,306	164,102	3,557,118	3,876,450
Different County	2,553	2,458	13,051	10,858	145,864	130,074	2,186,293	2,190,419
Same State	1,952	1,865	9,636	8,015	103,880	92,806	1,458,672	1,463,942
Different State	601	593	3,415	2,843	41,984	37,268	727,621	726,477
Elsewhere in 1995	49	93	737	1,355	6,857	10,783	613,724	720,748
NATIVITY & PLACE OF BIRTH								
Total Population	28,395	28,387	65,566	61,908	777,584	794,293	17,990,455	18,976,457
Native	27,153	27,485	61,901	57,865	743,464	755,357	15,138,594	15,108,324
Born in United States	26,984	27,285	61,194	56,688	736,709	748,318	14,516,266	14,589,263
State of Residence	24,178	24,794	52,415	48,478	617,916	628,637	12,147,209	12,384,940
Different State	2,806	2,491	8,779	8,210	118,793	119,681	2,369,057	2,204,323
Born Outside United States	169	200	707	1,177	6,755	7,039	622,328	519,061
Foreign Born	1,242	902	3,665	4,043	34,120	38,936	2,851,861	3,868,133
Entered 1990 to March 2000	123	93	969	1,623	9,091	14,044	1,189,865	1,561,609
Naturalized Citizen	987	729	2,465	2,241	21,671	22,917	1,297,020	1,783,744
Not a Citizen	255	173	1,200	1,802	12,449	16,019	1,554,841	2,084,389

Profile of Selected Social Characteristics: 1990 & 2000

[redacted]

Profile of Selected Social Characteristics	Town of Rotterdam		City of Schenectady		Capital District		New York State	
	1990	2000	1990	2000	1990	2000	1990	2000
REGION OF BIRTH OF FOREIGN BORN								
Total (excluding Born at Sea)	1,208	902	3,578	4,043	33,070	38,936	2,692,871	3,868,094
Europe	888	666	2,244	1,639	17,650	14,998	842,395	879,307
Asia	108	124	796	952	8,898	13,147	633,421	916,597
Africa	4	10	85	245	788	1,784	55,819	116,936
Oceania	8	0	0	25	93	183	5,004	7,680
Latin America	150	85	309	1,013	3,432	6,298	1,174,849	1,891,612
North America	55	17	235	169	2,964	2,526	58,142	55,962
LANGUAGE SPOKEN AT HOME								
Population 5 & Older	26,737	26,762	60,408	57,624	724,438	746,408	16,743,048	17,749,110
English Only	24,538	24,872	53,699	50,187	670,256	685,056	12,834,328	12,786,189
Language Other Than English	2,199	1,890	6,709	7,437	54,182	61,352	3,908,720	4,962,921
Speak English Less Than "Very Well"	1,161	810	3,094	2,423	20,722	19,299	1,892,862	2,310,256
Spanish	201	278	1,302	2,727	10,238	16,728	1,848,825	2,416,126
Speak English Less Than "Very Well"	84	92	399	862	2,935	5,086	900,906	1,182,068
Other Indo-European Languages	1,879	1,467	4,825	3,699	35,875	32,549	1,446,881	1,654,540
Speak English Less Than "Very Well"	676	619	1,584	1,158	10,842	9,137	537,678	663,874
Asian & Pacific Island Languages	92	86	361	558	5,848	8,580	459,873	671,019
Speak English Less Than "Very Well"	40	60	164	226	2,557	3,899	278,017	395,159
ANCESTRY (Single or Multiple)								
Total Population	28,395	28,387	65,566	61,908	777,584	794,293	17,990,455	18,976,457
Total Ancestries Reported	40,192	36,705	87,254	70,134	1,075,863	963,076	21,349,480	20,381,381
Arab	48	97	221	283	3,183	3,565	95,837	121,925
Czech (1)	146	197	298	267	3,480	4,498	78,534	76,820
Danish	151	91	198	188	4,183	3,209	47,058	38,587
Dutch	1,872	1,538	3,132	2,070	41,700	30,764	369,807	272,904
English	3,782	2,752	7,079	4,604	116,146	85,904	1,566,123	1,140,036
French (except Basque) (1)	2,577	2,428	6,217	3,700	82,840	63,059	627,436	479,199
French Canadian (1)	756	689	1,667	1,077	23,275	21,534	157,750	151,839
German	6,477	4,879	12,163	7,554	173,318	131,496	2,900,879	2,122,620
Greek	130	135	366	261	4,807	4,446	159,876	159,763
Hungarian	266	193	437	397	5,044	4,663	186,898	137,029
Irish (1)	5,812	5,854	14,145	9,795	207,134	185,994	2,802,459	2,454,469
Italian	9,004	9,364	15,250	12,168	133,809	135,701	2,843,872	2,737,146
Lithuanian	275	163	416	265	4,493	3,847	70,397	49,083
Norwegian	136	73	286	168	4,337	4,997	90,158	90,524
Polish	3,723	3,751	7,256	5,568	66,278	57,470	1,181,077	986,141
Portuguese	38	31	113	57	1,248	1,190	44,090	43,839
Russian	170	153	1,103	690	14,039	11,893	596,583	460,261
Scotch-Irish	305	263	734	565	12,022	10,389	165,952	138,844
Scottish	813	557	1,242	1,010	19,546	16,800	266,312	212,275
Slovak	415	147	592	119	6,498	2,191	118,045	37,863
Subsaharan African	0	2	167	771	1,181	3,453	69,425	166,508
Swedish	329	313	701	338	8,861	6,644	165,333	133,788
Swiss	166	49	125	104	2,373	1,797	46,873	38,721
Ukrainian	244	104	291	290	8,091	7,605	121,113	148,700
United States or American	574	863	1,248	1,686	18,722	30,724	468,760	717,234
Welsh	148	144	400	277	6,277	6,164	103,679	85,356
West Indian (excluding Hispanic Groups)	8	29	241	491	2,330	3,526	476,563	685,874
Other Ancestries	1,827	1,846	11,166	15,371	100,648	119,553	5,528,591	6,494,033

(X) Not Applicable

(1) The data represent a combination of two ancestries shown separately in Summary File 3.
Czech includes Czechoslovakian French includes Alsatian
French Canadian includes Acadian/Cajun Irish includes Celtic.

Note: Data for Towns with Villages include the Village data

2.2 Nearby Industrial, Transportation and Military Facilities

2.2.1 Locations and Routes

The RCF is located near the commercial and residential center of Schenectady. The only nearby industrial facility is a steel plant occupying some of the old ALCO structures. A railroad track that sees heavy freight traffic is less than a kilometer to the south. The New York State Thruway is about 8 kilometers to the southwest. The Schenectady County Airport is located 3 km to the north/northeast.

2.2.2 Air Traffic

The largest airport in the area is the Albany International Airport, located roughly 7 miles (11.3 km) to the southeast of the RCF. None of the runways aim in the direction of the facility.

The Schenectady County Airport is 3 km N/NE of the RCF. The main runway, used primarily by Air National Guard C-130 transport planes, lines up fairly well with the facility. Due to the low profile of the RCF, it is highly unlikely that an airplane would accidentally strike the facility. Such an impact would totally destroy the reactor; though radiological consequences would be minimal (see Chapter 13).

2.2.3 Analysis of Potential Accidents at the Facilities

There are no facilities located near the RCF that have a significant potential for accidents that would affect operation of the reactor. There are no major transportation routes very near the facility. Airplane crashes in the vicinity of the building are considered to be very low probability.

2.3 Meteorology

2.3.1 General and Local Climate

The climate at Schenectady is primarily continental in character but is subjected to some modification from the maritime climate, which prevails in the extreme southeastern portion of New York State. The moderating effect on temperatures is more pronounced during the warmer months than in the cold winter season when outbursts of cold air sweep down from Canada with greater vigor than at other times of the year. In the warmer portion of the year, temperatures rise rapidly during the daytime to moderate levels. On the average, there are only 9 days per year with maximum temperatures of 90 degrees or above at Schenectady. The highest temperature on record is 104 degrees. As a rule, temperatures fall rapidly after sunset so that the nights are relatively cool and comfortable.

Winters are usually cold but not commonly severe. Daytime maximum temperatures in the months of December, January and February average around 37 or 38 degrees; the minimum during the night is about 20 degrees. On the average, there is an expectancy of 9 days during the year with sub-zero temperatures and the minimum temperature of record is 26 degrees below zero. Snowfall averages about 50 inches annually and the number of days in which one inch or more of snow covers the ground is approximately 50.

The precipitation at Schenectady is derived from moisture-laden air that is transported from the Gulf of Mexico and the Atlantic Ocean. Instrumental in the importation of this air are cyclonic systems which progress from the interior of the country northeastward over the St. Lawrence Valley, and also similar systems that move northward along the Atlantic Coast. It is only occasionally that the centers of these storms pass directly over Schenectady. Nevertheless, the area enjoys sufficient precipitation in most years to adequately serve the requirements of water supplies, agriculture and power production. Only occasionally do periods of drought conditions become a threat. The months of heaviest rainfall are from May through October, when the average monthly totals range between 3 and 4 inches per month. The greatest rainfall to occur in any individual month is 13.48 inches, while the least amount is 0.08 inches. Thundershowers are infrequent during the winter, although they have been recorded for each month in the year. The mean number for the period of record is 22 annually. A considerable portion of the rainfall in the warmer months is supplied by storms of this type, but they are not usually attended by hail of any consequence.

On the whole, wind velocities are moderate. The prevailing wind direction from May through November is from the south; from the north in January, and from the west in the remaining months of the year.

Generally speaking, November, December and January are cloudy months, but the remainder of the year is comparatively sunny with abundant sunshine to be expected in June, July and August. In fact, the average number of cloudy days for the three summer months is only 7 or 8. Usually there are only a few days in the year when the relative humidity of the air causes personal discomfort to a great degree.

The extremes of atmospheric pressure over the 75-year period of record leading up to 1983 range from 28.46 to 31.10 inches of mercury.

With only those differences which are the result of differing latitudes, and topographical effects, the climate of Schenectady is representative of the humid area of the Northeastern United States.

2.3.2 Site Meteorology

In addition to meteorological data taken during 1956-57 at the facility, very complete records covering many years are available from the U.S. Weather Bureau in Albany. The Meteorology station at the Albany Airport is approximately 7 miles to the southeast and on a relatively level plain with an elevation approximately 120 feet above the RCF site. General land contours toward the southeast rather abruptly rise from an elevation of 230 feet at the site on the bank of the Mohawk River to the elevation of the Albany Airport within ½ mile from the site. The differences in the data taken at the facility and the Albany Airport are no doubt influenced by the difference in location and the relatively poor statistics of facility data collected during a period of just 18 months.

2.3.2.1 Temperature

Temperature data for the Albany area is provided in Tables 2.1 and 2.2.

Table 2.1: Average Temperatures in Albany, New York

Average Temperature (°F)

Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
20.6	23.5	34.3	46.4	57.6	66.9	71.8	69.6	61.3	50.2	39.7	26.5

(www.cityrating.com)

Table 2.2: Temperature Data for Albany, New York

	Temp. (°F)	Relative Humidity (Percentage)		Extreme Temp. (Days Per Month)		Rain (Inches)	Cloudiness (Days Per Month)		
	Average	A.M.	P.M.	Below 32°	Above 90°	Average	Clear	Partly Cloudy	Cloudy
January	20.6	78%	64%	29	0	2.4	5	8	18
February	23.5	77%	58%	26	0	2.3	6	7	15
March	34.3	76%	54%	24	0	2.9	6	8	17
April	46.4	72%	49%	12	N/A	3.0	5	8	16
May	57.6	76%	52%	1	N/A	3.4	5	9	16
June	66.9	79%	56%	0	2	3.6	5	11	13
July	71.8	81%	55%	0	4	3.2	6	13	12
August	69.6	86%	58%	0	2	3.5	7	12	13
September	61.3	89%	60%	1	N/A	3.0	8	10	12
October	50.2	86%	58%	8	0	2.8	8	9	14
November	39.7	82%	63%	18	0	3.2	4	8	18
December	26.5	80%	65%	27	0	2.9	5	7	19
Annual	**47.4**	**80%**	**58%**	**147**	**8**	**36.2**	**69**	**111**	**185**

(www.cityrating.com)

2.3.2.2 Precipitation

Rainfall statistics for the Albany area are provided in Table 2.3. Snowfall data are shown in Table 2.4. The record maximum snowfall is 112.5" during the winter of 1970-71.

Table 2.3: Rainfall Data for Albany, New York

Rain (Inches)

Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2.4	2.3	2.9	3.0	3.4	3.6	3.2	3.5	3.0	2.8	3.2	2.9

(www.cityrating.com)

Table 2.4: Snowfall Data for Albany, New York

Season Oct-May	Snowfall (Inches)	Season Oct-May	Snowfall (Inches)	Season Oct-May	Snowfall (Inches)	Season Oct-May	Snowfall (Inches)
1984-85	41.3"	1989-90	57.9"	1994-95	30.9"	1999-00	62.1"
1985-86	62.5"	1990-91	28.7"	1995-96	86.5"	2000-01	77.1"
1986-87	80.6"	1991-92	30.7"	1996-97	66.6"	2001-02	47.4"
1987-88	76.7"	1992-93	94.2"	1997-98	52.3"	**1912-13**	**Min: 13.8"**
1988-89	19.0"	1993-94	88.1"	1998-99	44.1"	**1970-71**	**Max: 112.5"**

(www.wrgb.com)

2.3.2.3 Winds

Periodic wind observations for the period September 1956 through December 1957 at the facility site are shown in Figure 2.4. Note that winds from the northwest quadrant occur a total of 28.9% of the time with an average velocity of 8.9 miles per hour (4.0 meters per second). Therefore, prevailing winds can be considered as originating in the northwestern quadrant and affecting the populated area of Schenectady about 29% of the time. Similar data for the Albany Airport for the year 1992 are shown in Figure 2.5.

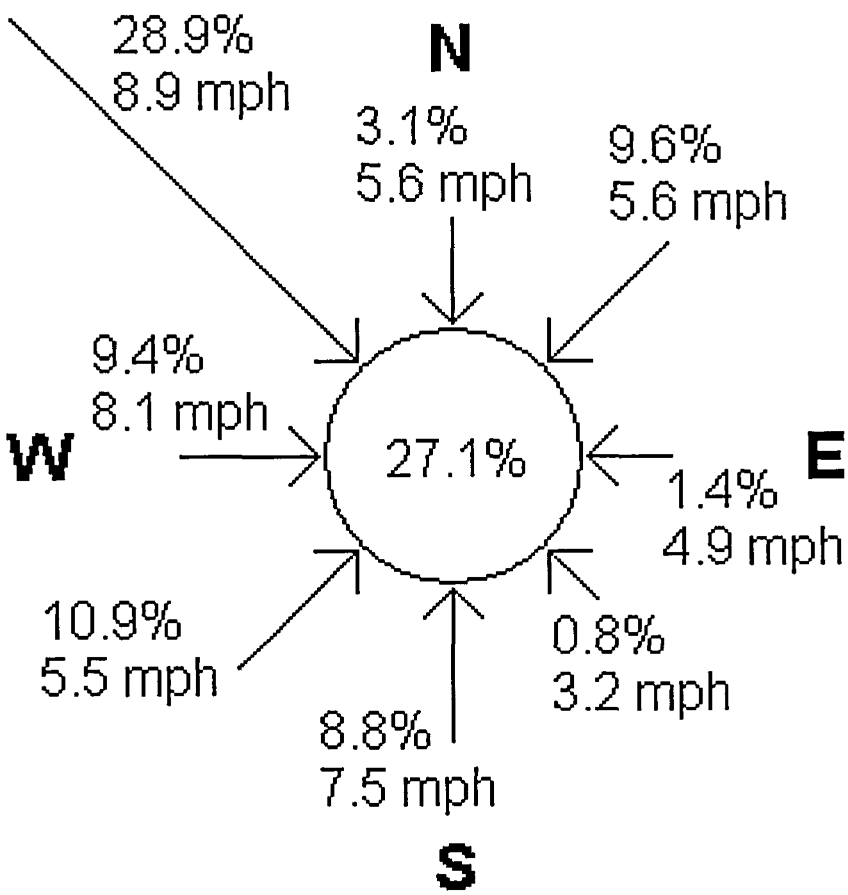
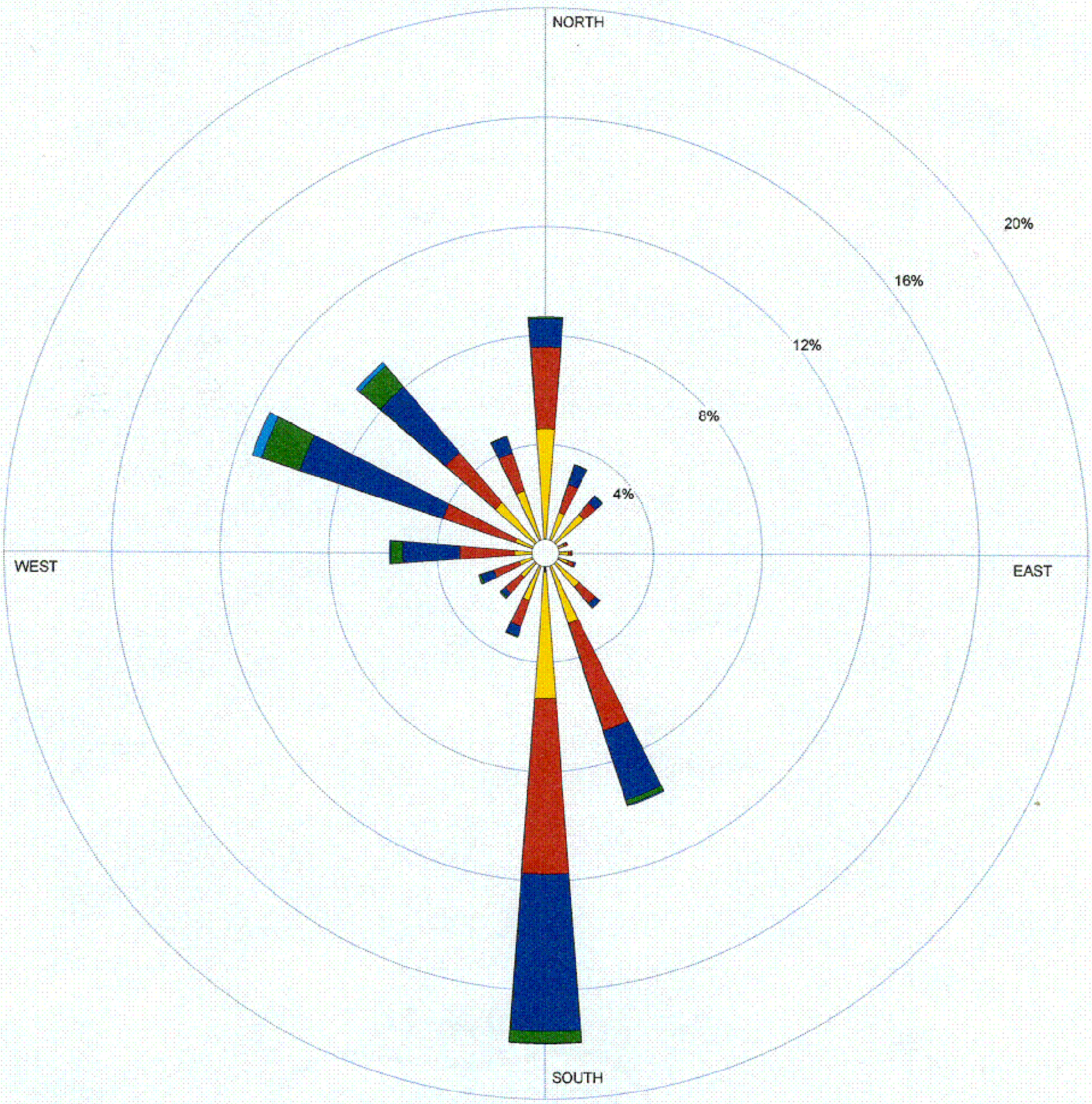


Figure 2.4: Average Annual Frequency of Surface Wind Direction at the RCF

WIND ROSE PLOT

Station #14735 - ALBANY/COUNTY ARPT, NY



Wind Speed (m/s)			
> 11.06 8.49 - 11.06 5.40 - 8.49 3.34 - 5.40 1.80 - 3.34 0.51 - 1.80	MODELER	DATE **10/1/02**	COMPANY NAME
	DISPLAY **Wind Speed**	UNIT **m/s**	COMMENTS
	AVG. WIND SPEED **4.55 m/s**	CALM WINDS **12.67%**	
	ORIENTATION **Direction (blowing from)**	PLOT YEAR-DATE-TIME **1992 Jan 1 - Dec 31 Midnight - 11 PM**	PROJECT/PLOT NO.

WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com

C01

2.4 Hydrology

Schenectady County lies almost entirely within the lowland area bounded by the Adirondack Mountains on the north, and by the Helderberg escarpment of the Allegheny Plateau province on the south. The lowland has been deeply eroded and has considerable relief. The altitude of the county ranges from about 200 feet above sea level in the flood plain of the Mohawk River to about 1100 feet at Glenville Hill on the north side of the Mohawk, and to more than 1400 feet in the hills near the center of the county on the south side of the Mohawk.

The Mohawk River enters the county at the village of Hoffmans and flows south-easterly for about 9 miles on a flood plain about a mile wide, until it reaches the city of Schenectady. There, the flood plain flares out to a width of more than 2 miles and the river changes its direction of flow to the northeast. About 4 miles farther downstream, the river bends again to the southeast and continues in that direction through a narrow rock channel, about 100 feet deep, almost until it leaves the county near the village of Niskayuna. All drainage in the county is to the Hudson River, mostly via the Mohawk River.

At the southern edge of the flood plain of the Mohawk River, in the area of the facility site, the land surface rises rather abruptly within ½ mile, from an altitude of about 230 feet to 350 feet above sea level. The higher level is a sand plain, in a youthful stage of dissection, which extends from Schenectady south-eastward toward Albany. Most of the residences in the county are built on this sand plain.

An average of more than 25 million gallons of ground water is pumped daily in Schenectady County. Ground water is the source of every municipal supply and water district in the county with the small exception of the village of Delanson. In addition, several thousand wells have been drilled, driven, or dug to supply ground water to suburban and rural homes and farms. Municipal supplies serve approximately 100,000 people, or about 80 percent of the area population, and several large industries including the General Electric Company and the Knolls Atomic Power Lab. The principal pumpage is from an unconsolidated gravel deposit underlying the Mohawk River between the city of Schenectady and the village of Scotia. This deposit is relatively small in size, but has produced large volumes of water continuously for more than half a century with no sign of depletion, undoubtedly because of recharge to the gravel from the Mohawk River.

Except for ground water derived from river recharge, essentially all potable ground water in the county originates from precipitation that falls on the surface of the county and its immediate vicinity. At any given spot, the direction of ground water movement is ordinarily toward the nearest stream channel. The movement is usually under water-table conditions, and although artesian horizons are found locally, flowing wells are scarce.

Underlying more than 90% of the county, the Schenectady formation is its most widespread consolidated-rock aquifer, consisting of an alternating series of shale and sandstone beds as much as 2,000 feet thick. This formation and the other bedrock formations of the county are essentially impervious to the flow of ground water, except insofar as they contain joint openings and bedding planes. Such openings are difficult to anticipate and generally tend to pinch out with depth. Yields from the rocks wells show a considerable range and depend in large part on the thickness and nature of the overburden. In general, the yield is greatest (up to 150 gallons per minute) where the overburden consists of gravel or sand, and least (as low as 1 gallon per minute or less) where the overburden consists of clay or till. In most places, however, the consolidated rock will yield to drilled wells, ranging from about 50 feet to about 250 feet deep, enough water of satisfactory quality for domestic or farm needs. The mineral content of water from rock wells ranges over wide limits, both in hardness and in dissolved solids. The hardness may range from very high to very low, but the dissolved solids are rarely low. The water from some wells is so highly mineralized as to be undesirable for most uses. Hydrogen sulfide gas in small amounts is not uncommon; traces of natural gas are occasionally found; carbonated mineral water of the Saratoga Springs type was found in one well.

Unconsolidated deposits of glacial origin, consisting of till, clay, sand, and gravel, mantle the consolidated rocks almost everywhere. Glacial till is the most widespread of the unconsolidated deposits and, in Schenectady County, is dense and almost impervious, yielding only a few hundred gallons of water per day to large diameter dug wells. Deposits of till up to about 300 feet thick are found, but ordinarily the deposits are less than 50 feet thick. Clay of alluvial or lacustrine origin, which is much less common than till, will yield about the same quantity of water to large diameter dug wells.

By far the largest quantity of water is pumped from deposits of sand and gravel of relatively limited size. Most of these deposits occur along the principal stream channels. A deposit of sand occurs over a wide area in the section south of the city of Schenectady and in scattered places elsewhere in the county. Hundreds of shallow wells have been driven into the sand, usually yielding ample water for all domestic needs. The most productive aquifers in the county are part of a series of more or less interconnected deposits of sand and gravel that underlie the Mohawk River flood plain from the city of Schenectady upstream approximately 8 miles to Hoffmans. This series is the source of all the ground water pumped from municipal use in the county. The individual wells yield as much as 3,000 gallons per minute with relatively small drawdowns.

The water from the unconsolidated deposits is generally acceptable for industrial or municipal use; usually without treatment. Small portions of water are treated for particular industrial uses. Dissolved solids rarely exceed 500 ppm and hardness is usually less than 300 ppm. Iron or manganese is occasionally found in high-enough concentration to be troublesome.

Test borings were originally taken at the site about 100 feet from the southeast bank of the Mohawk River. Three holes were drilled; two to a depth of 25 feet, and one to a depth of 70 feet. The natural soil from 15 to 70 feet below the surface is classified as a fine, relatively uniform silt or silty sand with considerable evidence that much of the material is organic. The particle sizes range from 0.4 to less than 0.001 mm in diameter with the "50% finer than" point at 0.05 mm.

Artificial fill consisting of cinders, sand and brick in varying degrees of compactness was noted to a depth of 15 feet below the surface. The apparent ground water level was reached at a depth of 12 feet, which compares closely to the elevation of the Mohawk River.

Because of the character of this unconsolidated material, the Critical Facility building was supported by a reinforced concrete foundation resting on 104 treated wooden piles driven to a depth of 50 feet. Each pile is rated for a 20-ton bearing pressure.

Flooding records kept by ALCO Products since 1914 are summarized in the table below. This indicates a general flooding of the plant on several occasions, with some flooding in buildings. No structural damage of significance has been experienced. From the last recorded high water in February 1939 to January 1956 there have been no floods exceeding an elevation of 227 feet. The floor level of the facility is at 230 feet, so no serious threat is anticipated in this respect. Precautions, however, were taken to minimize or prevent damage which could result in the uncontrolled release of activity in a severe flood.

Table 2.5: Maxima Recorded High Water at ALCO Products, Plant #1

Date	Elevation (ft.)
March 28, 1914	232.0
April 2, 1916	229.0
February 20, 1918	227.3
February 12, 1925	227.0
March 15, 1929	227.1
March 19, 1936	228.0
February 21, 1939	227.5

Since 1939 there have been no water levels exceeding an elevation of 227 feet.

2.5 Geology, Seismology, and Geotechnical Engineering

2.5.1 Geology

Rock underlying Schenectady County were deposited in two widely separated eras; in early Paleozoic time and in late Cenozoic time. The Paleozoic rocks consist mostly of alternate layers of shale and sandstone deposited in shallow Ordovician seas as clay, silt, and sand. These sediments were buried by younger sediments, consolidated, raised above sea level, and subjected to erosion and weathering (after removal of younger sediments) during succeeding geologic time. The rocks in the eastern part of the county are folded and faulted, having been affected by crustal deformation originating near what is now New England.

The Paleozoic rocks are mantled almost everywhere by unconsolidated glacial drift deposited during Pleistocene time. During this period, a continental ice sheet that originated in Labrador repeatedly advanced and retreated across the entire state. In some areas, the glacier eroded the rocks deeply, and in other areas it laid down thick deposits of unconsolidated material. It is believed that during the final stage of ice advance, called the Wisconsin stage, the glacier was thick enough to submerge completely the highest peaks in the Adirondack and Catskill areas. The Wisconsin ice advance within Schenectady County seems to have removed or reworked all or almost all the material that had been deposited during the previous advances of the ice sheet. Wisconsin deposits in Schenectady consist mainly of glacial till containing a high percentage of clay and of fluvioglacial deposits of gravel, sand and clay. In addition, smaller deposits of clay, silt and sand have been deposited on the flood plains of the larger streams in the county during recent time.

The structure of most of the consolidated rocks in Schenectady County is relatively simple. Almost the entire county is underlain by the Schenectady formation, a series of alternating beds of shale, sandstone and grit about 2,000 feet thick which dip gently west and southwest. In most places the dip ranges from 1° to 2°, but in places it is as much as 5°. Although the Schenectady formation has never been subjected to stresses sufficient to produce folding, its continuity near the surface is broken by sets of intersecting nearly vertical joints.

2.5.2 Seismology

N.H. Heck's "Earthquake History of the United States", which reports on all recorded disturbances to 1927, indicates there have been two tremors in the immediate Schenectady area. These occurred on January 24, 1907 and in February 1916. The former had an intensity of 5; and the latter, 4 to 5 on the Rossi-Forel scale of intensity. A quake with this intensity is described as a moderate shock, generally felt by everyone, and with some disturbance of furniture and ringing of bells. No damage results to a structurally sound building at this intensity level.

2.5.3 Maximum Earthquake Potential

Figure 2.6 shows seismic hazard (as determined by USGS) in %g for the United States. The Albany, NY area lies on the boundary of "2-4" and "4-8" zones; therefore, seismic hazard for Albany can be estimated as 0.04 g.

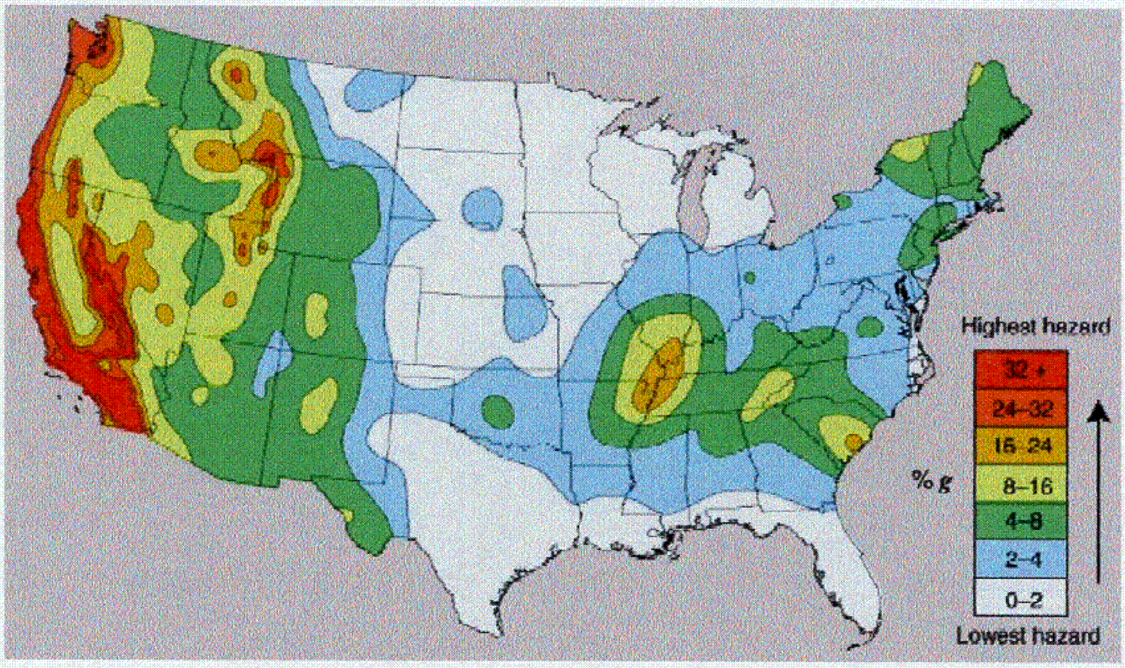


Figure 2.6: Seismic Hazard Map

2.5.4 Vibratory Ground Motion

Due to a lack of data from historical seismic events, the most reasonable way to characterize vibratory ground motion is via the seismic hazard value of 0.04 g from the previous section.

2.5.5 Surface Faulting

Given the seismic history of the area, surface faulting is not considered to be a likely event.

2.5.6 Liquefaction Potential

As is the case with surface faulting in the previous section, the liquefaction potential is not considered to be significant.

C02

3. DESIGN OF STRUCTURES, SYSTEMS AND COMPONENTS

3.1 Design Criteria

Since RPI assumed ownership of the Reactor Critical Facility, the primary design criterion has been minimization of offsite radiation exposure. This has been achieved in several ways. A decision by RPI administration to limit operation to 15 watts ensures that radiation levels at the site boundary during and after reactor operation remain low. The walls of the facility are concrete, and are at least a foot thick at all locations. The design of the fuel pins minimizes the risk of fission product release. The ventilation system is also designed to prevent release of fission products from the facility.

The Technical Specifications (Chapter 14) list rules regarding core conditions, scram setpoints, and other conditions ensuring that the reactor status is always within the limits accounted for by the design criteria. This includes the design basis accident described in Chapter 13.

3.2 Meteorological Damage

The Schenectady area experiences very few extreme wind conditions, such as tornadoes or hurricanes. Furthermore, the reactor room is constructed of poured reinforced concrete walls, 0.3 m thick on three sides and 1 m thick on the fourth side. Such a structure makes damage to the reactor from the infrequent, high-velocity winds improbable.

3.3 Water Damage

The reactor building floor is of poured concrete at an elevation of 70 m, and the reactor tank and fuel storage vaults are at least 1 m above floor level. The highest flood level of the Mohawk River was recorded 70.7 m in 1914 (Table 2.5). No other floods of record have reached the elevation of the reactor room floor. Even though future flooding of the building from the Mohawk River can not be ruled out, the probability is low, and the impact on the fuel in the storage vault or the reactor is not considered to be significant.

3.4 Seismic Damage

From Figure 2.6 it can be seen that seismic risk at the RCF is low. Because the RCF building is solidly constructed, it has been concluded that the risk of seismic damage to the reactor facility is small.

3.5 Systems and Components

The mechanical systems important to the safe operation of the RCF are the neutron-absorbing control rods suspended from overhead drive systems. These drive systems are mounted on and supported by the reactor tank. The motors, gear trains, electromagnets, switches, and wiring are above the level of the top of the tank, and therefore readily accessible for visual inspection, testing and maintenance. A preventative maintenance program has been in effect for many years at the RCF to ensure that operability of the reactor systems is in conformance with the performance requirements of the Technical Specifications.

The history of operation of the RCF indicates few malfunctions of electro-mechanical systems and no persistent malfunction of any one component, and thereby attests to the effectiveness of the maintenance program (see Inspection Reports from the Office of Investigation and Enforcement and licensee reports of Reportable Occurrences, Docket No. 50-225). Therefore, the staff concludes that there is reasonable assurance that continued operation of the RCF will not increase the risks to the public.

4. REACTOR DESCRIPTION

4.1 Summary Description

The RCF reactor, pictured in Figure 4.1, is a "zero power", light-water moderated reactor. The core consists of an [redacted] The most commonly used fuel pin configuration utilizes a [redacted] (Figure 4.2). The core rests on the floor of a 2000-gallon stainless steel tank and typically operates at a steady-state power level below 1 watt. The reactor is never operated at a power level above 15 watts, eliminating the need for a cooling system. There is a [redacted] Auxiliary electric heaters are optionally placed in the reactor tank to heat up the water if desired.

Several reactor parameters are summarized in Table 4.1.

[redacted]

Table 4.1: RCF Reactor General Parameters

Self-Imposed Max Power Limit,	[redacted]
Effective Delayed Neutron Fraction,	[redacted]
Effective Neutron Lifetime,	[redacted]
Fuel Type	[redacted]
Fuel Pin Clad	[redacted]
Active Fuel Length	[redacted]
Boron Control Rods	(4) Flux-Trap type
Moderator	Light Water, 2000 gal
Reactor Tank Dimensions	[redacted]

[redacted]

[redacted]

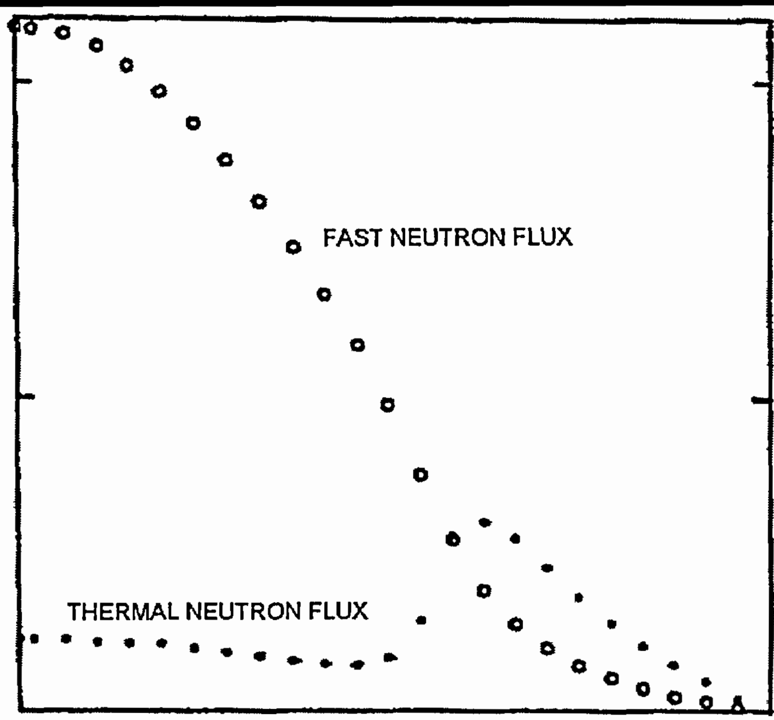


Figure 4.3: Core A Configuration and Flux Map

[redacted]

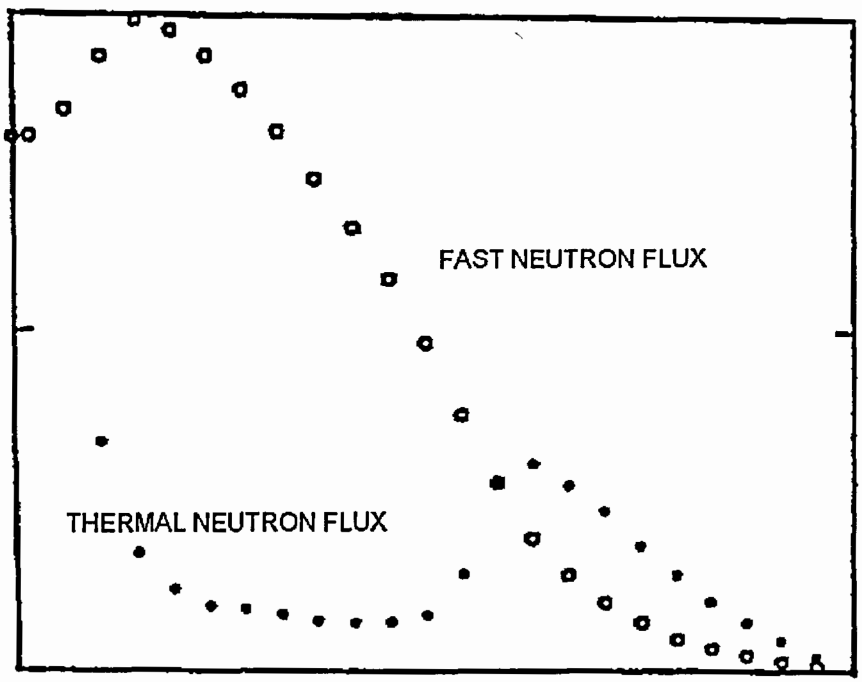


Figure 4.4: Core B Configuration and Flux Map

The core and support structure are designed for critical experiments using variable arrays of fuel pins. Two fuel pin arrangements are discussed here. The first, referred to as "Core A", [redacted]. The second, referred to as "Core B", is [redacted] The optional Core B permits use of the interior region for experimental purposes. All numerical values in this report refer to Core A unless otherwise specified.

4.2 Reactor Core

4.2.1 Reactor Fuel

The core [redacted] and NRC. Each fuel pin is made up of sintered UO_2 pellets, [redacted] capped on both ends with a stainless steel cap and held in place with a chromium-nickel spring. An aluminum oxide (Al_2O_3) insulator between the fuel pellets and stainless steel caps on each end of the rod is installed. Gas gaps to accommodate fuel expansion are also provided at both the upper end and around the fuel pellets. Figure 4.5 depicts a single fuel pin and its pertinent dimensions. Tables 4.2 through 4.4 provide detailed compositions of the fuel pins.

Table 4.2: Measurements and Specifications for SPERT (F-1) Fuel

	Argonne Requalification Data	Phillips Idaho Specifications
Clad OD (in.)	[redacted]	[redacted]
Clad ID (in.)		
Clad Length (in.)		
Weld regions OD (in.)		
Fill gas	He + H_2, 0.6 - 3.3 psig	He, 1 psig
UO_y density (g/cm^3), ρ	[redacted]	[redacted]
UO_y diameter (in.)	[redacted]	[redacted]
UO_y stack length (in.)	[redacted]	[redacted]
UO_y composition	[redacted]	
w/o U233		
w/o U234		
w/o U235		2-5
w/o U236		
w/o U238		
w/o U in oxide, W		[redacted]
Ca (ppmw)		
Cr (ppmw)		
Fe (ppmw)		
Mg (ppmw)		
Ni (ppmw)		
Impurity $\Sigma_{athermal}$ (cm-1)		
SS304 Composition	[redacted]	[redacted]
w/o Co		
w/o Cr		
w/o Cu		
w/o Fe		
w/o Mn		
w/o Mo		
w/o Ni		
w/o B		

[redacted]

[redacted]

[redacted]

4.2.2 Control Rods

Four control rods are provided, spaced 90 degrees apart at the core periphery. Each rod consists of a [redacted] which passes through the core and rests on a hydraulic buffer on the bottom carrier plate of the support structure. Housed in each of these "baskets" are two enriched boron absorber sections, one positioned above the other as depicted in Figure 4.6. The ^{10}B poison contained in each absorber section is held in an iron cement that is also clad with stainless steel. Each of the four rods has approximately the same reactivity effect.

The overhead control rod drives, four in number, are mounted on the reactor tank. Figure 4.7 offers a detailed view of one such mechanism. The drives are supported by rigid cantilevers with three degrees of freedom to allow positioning of the rods anywhere in the tank. Structurally, the drives consist of a 1/20 horsepower motor, gear box, magnetic clutch, drive shaft, pinion gear, and control rod rack. Control rod position is determined by a pair of geared anti-backlash synchromotors. Electrically, the control rods operate on demand from the control room, with power supplied to the magnetic clutches from the safety amplifiers. A minimum holding current is adjusted for each drive individually to minimize magnet decay time and therefore rod drop time. This current is interrupted on receipt of any scram signal or on power failure.

[redacted]

Figure 4.8 shows the excess reactivity of the core [redacted] It can be seen that only [redacted]

[redacted]

[redacted]

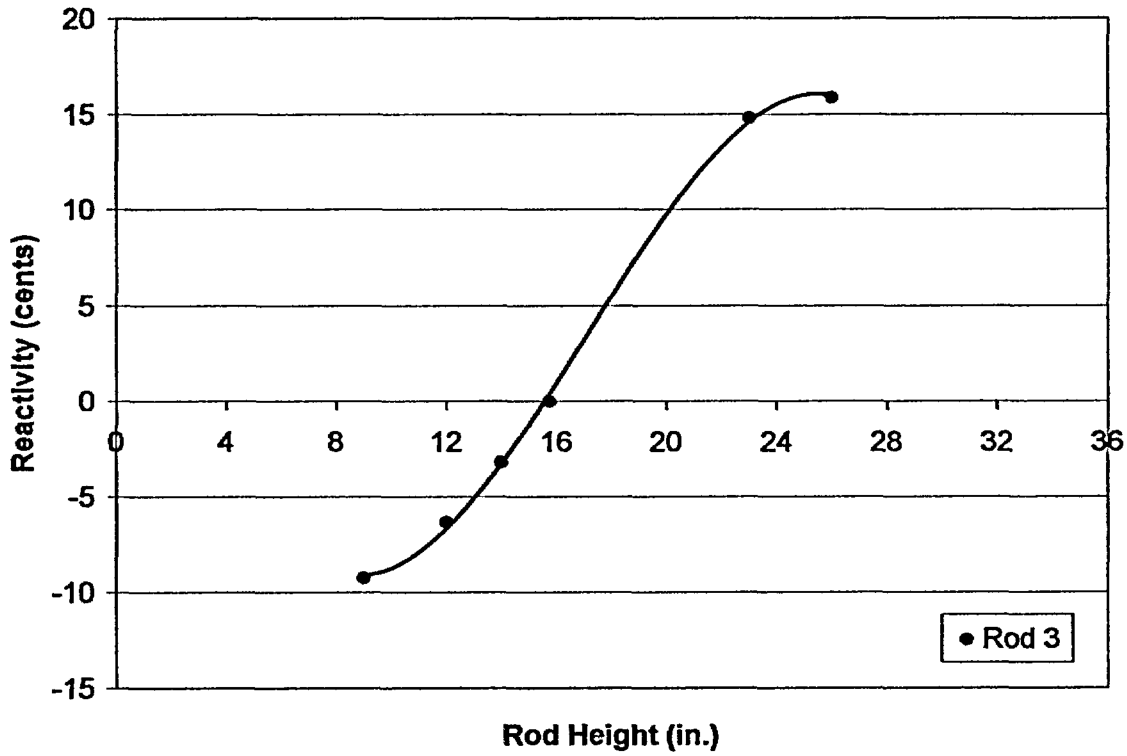


Figure 4.8: Integral Control Rod Worth

[redacted]

4.2.3 Neutron Moderator and Reflector

The RCF reactor uses light water in the reactor tank as the reflector and moderator. [redacted] When the reactor is not operating, the water is stored in a large storage tank beneath the reactor tank. Water may be added to the storage tank directly from the city water supply. A simple filtering system is connected to the storage tank as well. Water from the storage tank may be discharged to the Mohawk River after being tested for contamination.

Figure 4.9 shows the reflector/moderator water in the reactor tank. The figure is taken from the MCNP plot routine for a detailed RCF reactor model recently constructed in MCNP.

4.2.4 Neutron Startup Source

A [redacted] is used during reactor operation. Source emission rate is approximately 10^7 neutrons/second. The source is inserted into and withdrawn from the reactor via an attached [redacted] by means of a friction drive motor. In the withdrawn position, the source is enclosed [redacted] (Figure 4.10). The effect of inserting the source into the core can be seen in Figure 4.11.

[redacted]

[redacted]

4.2.5 Core Support Structure

The fuel pins are supported and positioned on a fuel pin support plate, drilled with [redacted] to accept tips on the end of each pin. The support plate rests on a thick carrier plate, which forms the base of a [redacted] support structure. An upper fuel pin lattice plate, depicted in Figure 4.2, rests on [redacted]nd is drilled through with [redacted] to secure the upper ends of the fuel pins. The carrier plate, the lower fuel pin support plate, a middle plate, the top plate, and the upper fuel pin lattice plate are secured with tie rods and bolts. The entire core structure is anchored by four posts set in the floor of the reactor tank. Finally, in the event that the fuel pins are bowed but still satisfactory for use in the core, a plastic spacer plate may be installed on the middle plate. Figure 4.12 depicts the total core assembly.

All structural components are [redacted]

[redacted]

4.3 Reactor Tank

The reactor tank, storage tank, pumps, valves, and all system piping are of stainless steel. This allows the use of untreated, city-supplied water without inducing corrosion or other water damage. The reactor tank structure, shown in Figure 4.13, is mounted at floor level and is supported by I-beams bridging the reactor room pit. A welded steel catwalk [redacted] the tank capacity is about 2000 gallons.

The cylindrical wall of the reactor tank is 1 cm thick and has no penetrations. The only penetrations in the floor of the reactor tank are for the fill line and fast dump line. Since the reactor operates at such low power levels, radiation damage to the tank is not a concern.

The storage tank, mounted horizontally and strapped to the depressed section of the reactor room pit, is seven feet in diameter and ten feet long. [redacted]

[redacted]

4.4 Biological Shield

Shielding for the reactor is provided by the water in the reactor tank [redacted] the reactor tank itself [redacted], and the concrete walls of the reactor room [redacted] At power levels in the range of 1 watt, this amount of shielding is more than sufficient. There are no penetrations that would result in "hot spots", and there is no heat-up of any shielding components.

4.5 Nuclear Design

4.5.1 Normal Operating Conditions

Typically, the core exists in the configuration described thus far in this chapter. However, there are some conditions that change periodically. As described in Section 4.1, there are two basic fuel pin configurations. Core A utilizes a solid octagonal array of fuel pins, and Core B (which is rarely used currently) is an annular array. Additionally, for Core A there are several lattice plates available with varying pitch. By far the most commonly used configuration is the [redacted] (Figure 4.14).

[redacted]

During thesis experiments or class labs, it is not unusual to remove or add a fuel pin to the core periphery [redacted], or to remove a fuel pin from the interior of the core to measure fuel pin worth. It is known that removing multiple fuel pins from interior sections of the core can result in significant reactivity addition, beyond the excess reactivity limit of 60 cents set in the Technical Specifications. The Technical Specifications provide instructions for analyzing an "unknown" core in order to prevent unintended high-reactivity configurations from becoming a problem. As a rule of thumb, there are never more than 2 fuel pins removed from the core interior simultaneously.

There are usually [redacted] in the core, and the excess reactivity of the core ranges between 10 and 35 cents, depending upon the pin configuration and water temperature. Water temperature is limited to a minimum of 50°F by the Technical Specifications.

MCNP is often used as an additional investigative tool to analyze the effect of changing the core configuration.

It should be noted that there are some conditions that change in most reactors that do not change in the RCF reactor. In particular, due to the low power levels of operation, the RCF fuel is always treated in calculations as undepleted.

4.5.2 Reactor Core Physics Parameters

Core physics parameters vary depending upon the fuel pin configuration. Typical ranges of some of these parameters are mentioned in Section 4.5.1. Parameters such as excess reactivity are recorded for all "known" (as defined by the Technical Specifications) fuel pin configurations.

4.5.3 Operating Limits

Some operating limits are described in Section 4.5.1. All operating limits are defined in the Technical Specifications (Chapter 14).

4.6 Thermal-Hydraulic Design

The maximum allowed power level of the RCF reactor is too low to heat the water in the reactor tank. Therefore, there are no thermal-hydraulic issues associated with the reactor.

5. REACTOR COOLANT SYSTEMS

The maximum design power of 100 watts results in negligible heat up of the 2000 gallons of water in the reactor tank. Therefore, the RCF reactor does not require cooling.

The facility piping diagram is provided in Figure 5.1 for information.

[redacted]

6. ENGINEERED SAFETY FEATURES

Engineering safety features are not required for the RCF reactor due to the low operating power levels. Fission product inventories are minimal [redacted] A filter is provided on the reactor room ventilation stack to reduce the possibly of fission product release from the facility even further.

7. INSTRUMENTATION AND CONTROL SYSTEMS

7.1 Summary Description

The RCF Reactor is designed for steady-state operation only. All operations are performed from two control panels in the control room [redacted] All instrumentation is currently analog; however, substantial equipment upgrades are in progress. Linear and log power/period monitors will be replaced with digital instrumentation, and all strip chart recorders will be replaced by digital plasma screen recorders.

7.2 Design of Instrumentation and Control Systems

7.2.1 Design Criteria

The instrumentation and control systems provide numerous functions, including rod position indication and movement control, and reactor power behavior. These systems also provide for automatic shutdown of the reactor if necessary. Redundancy is desired for anticipated possible problems with instrumentation.

7.2.2 Design Basis Requirements

The primary design basis requirement for reactor safety at the RCF is the safety limit on fuel pellet temperature listed in Section 2.1 of the Technical Specifications. Automatic scrams must be designed such that the temperature limit on the fuel is not reached.

7.2.3 System Description

The safety system channels that operate during reactor operation are specified in Section 3.2 of the Technical Specifications (Chapter 14). This indicates each channel's function and range of operation.

7.2.4 System Performance Analysis

I&C system functionality is thoroughly checked before any reactor startup. Scram setpoints and interlocks are also checked to ensure that the Technical Specifications are followed. Some of the instrumentation is very old, though it has been generally reliable. Regardless, an effort is underway to upgrade most of the instrumentation before it fails.

7.2.5 Conclusions

The RCF reactor has been operated successfully for decades with the existing instrumentation, and there is no reason to believe it will not continue to do so. Functionality of the I&C systems is frequently tested, and upgrades are in progress that will greatly improve reliability and precision of the instrumentation.

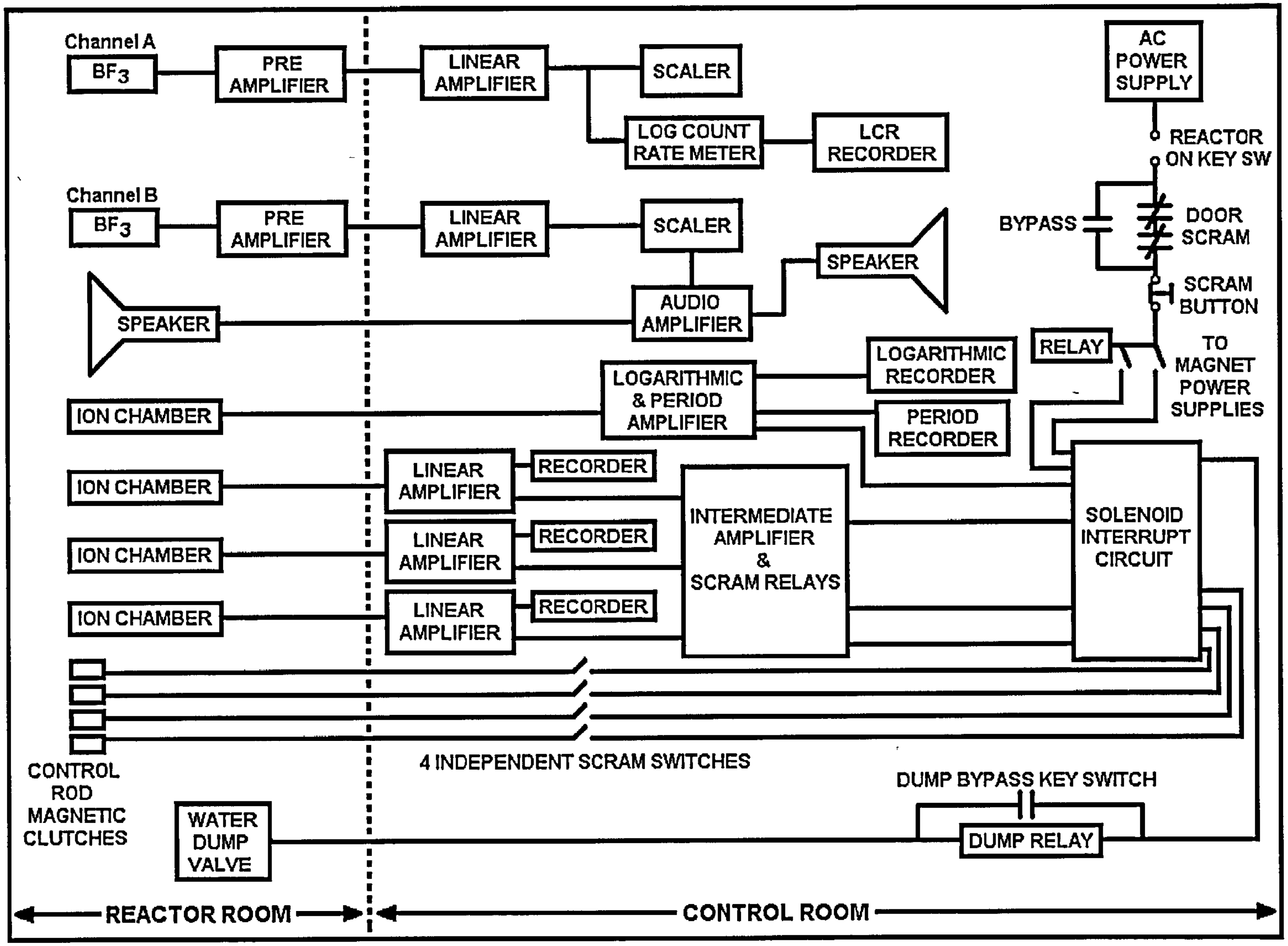
7.3 Reactor Control System

A block diagram of the control instrumentation is shown in Figure 7.1. Control of reactor power level must be performed manually. There is no automatic power level control capability.

The core has four control rods located at the periphery of the fuel lattice. Each drive gear box contains a lead screw actuating upper and lower limit switches, [redacted]f travel, and synchro transmitters for coarse [redacted] and fine [redacted] position indication. The drive switches and synchro receivers are mounted on the control room console. When there is a reactor scram, the rod drives clutch magnet current is interrupted and all rods drop. Additionally, the moderator is dumped when it is not bypassed. The control rods and moderator dump are to operate within the limits of Section 3.2 of the Technical Specifications.

Figure 7.2 shows the interlock system for the RCF reactor. The control rods will not move if any of the conditions shown in the diagram are not met:

- Fill pump off
- Period > 15 sec
- Chart recorder power on
- Source range instrumentation reading > 2 cps
- 400 Hz power on (control rod position indicators)



CONTROL INSTRUMENTATION BLOCK DIAGRAM

Figure 7.1: Control Instrumentation Block Diagram

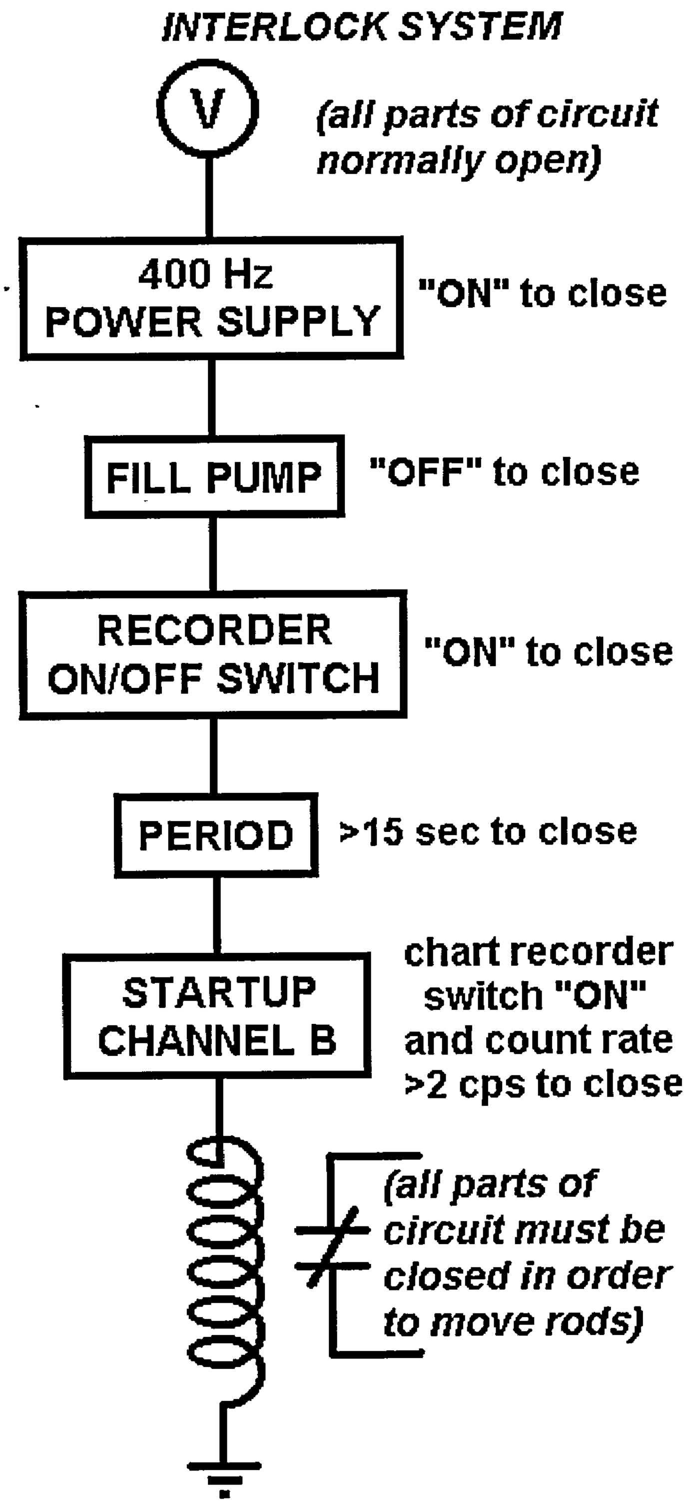


Figure 7.2: Interlock Block Diagram

7.4 Reactor Protection System

The scram circuit for the RCF is shown in Figure 7.3.

The nuclear instrumentation for control of the reactor consists of the following neutron flux detectors: 2 BF_3 counters (source range instrumentation), and 3 uncompensated ion chambers (2 linear amplifiers for intermediate range, 1 log amplifier for "power" range). The linear amplifiers will initiate a scram signal if the reading reaches 90% of the current range, and the log/period amplifier will cause a scram if the period falls below 5 seconds or the log power exceeds 135 W. The bases supporting the scram setpoints are outlined in the Technical Specifications.

There are also several manual scrams:

- Reactor console power (scram circuit power)
- Manual scram button
- Scram circuit key
- Reactor room door

7.5 Engineered Safety Features Actuation Systems

There are no engineered safety features actuation systems.

7.6 Control Console and Display Instruments

[redacted]

The neutron source yields about 10^7 neutrons/second, which is sufficient to maintain the source range rate above the minimum requirement for startup of 2 cps. The source is also sufficient to maintain the logarithmic count rate meter and linear amplifiers on scale at all times when the reactor is subcritical. The linear and logarithmic meters cover all necessary power ranges.

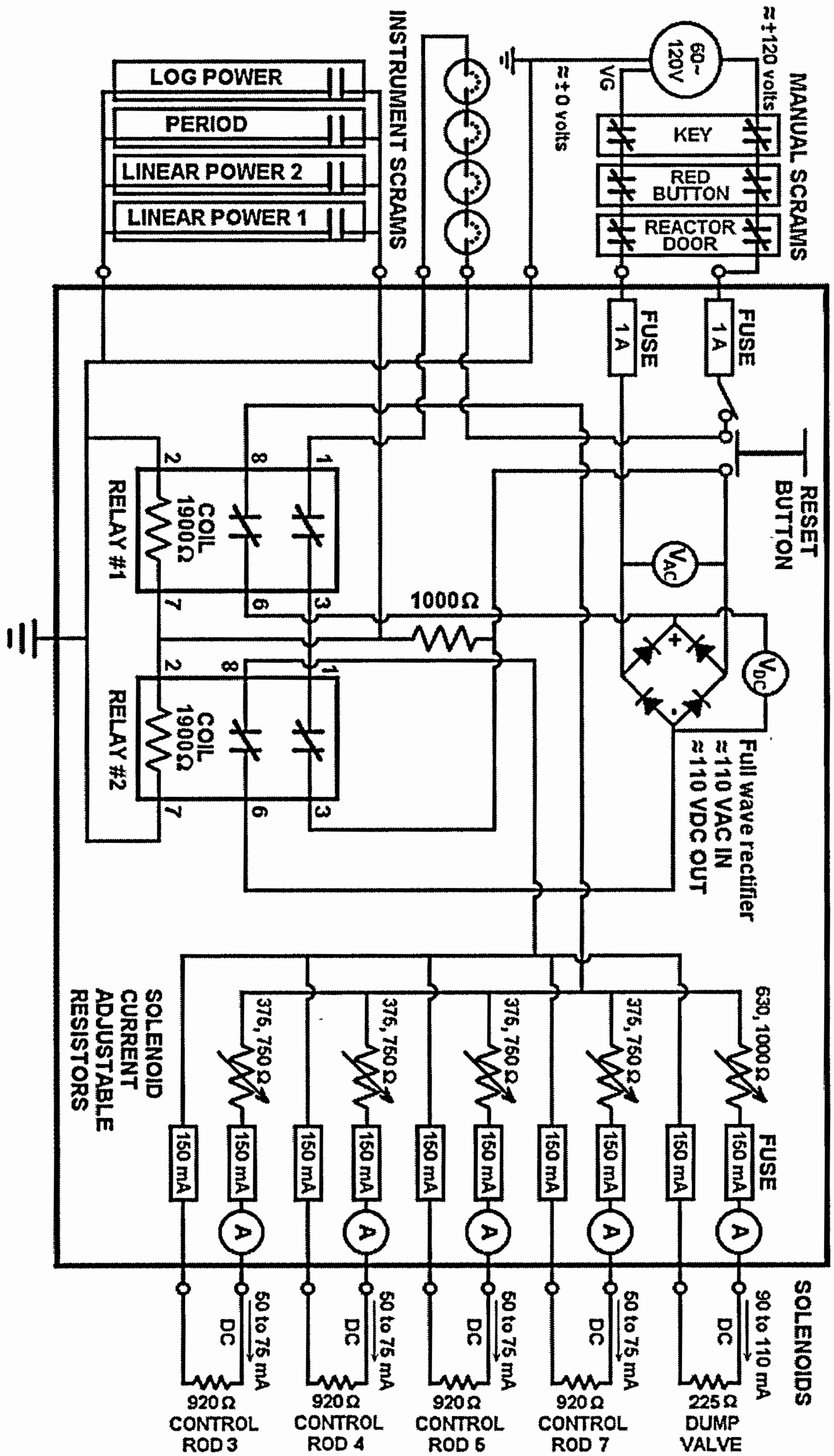


Figure 7.3: Scram Circuit

7.7 Radiation Monitoring System

In accordance with Section 3.3 of the Technical Specifications there is an area gamma monitoring system. Four G-M tubes are used, one at each of the following locations: control room, reactor room near the fuel vault (doubles as vault criticality monitor), reactor deck, and in the equipment hallway. Portable radiation monitors are also available. The area gamma monitors provide visual and audible indications.

The area gamma monitors are found in the following locations and have the following alarm setpoints:

- Control room: 10 mrem/hr
- Equipment hallway: 40 mrem/hr
- Outside vault (also acts as vault criticality monitor): 20 mrem/hr
- Reactor deck: 100 mrem/hr

Whenever the reactor is to be operated, the particulate activity of the reactor room atmosphere is monitored. The air monitor counts the beta-gamma activity on the filter paper through which a continuous 5 cfm sample of air is drawn from the stack duct. It provides audible and visual alarms if the count rate goes above 2000 cpm.

8. ELECTRICAL POWER SYSTEMS

8.1 Normal Electrical Power Systems

Electrical power to the facility is not necessary to keep the reactor safely shutdown. The electrical system at the RCF is similar to that which would be found in any other industrial structure of similar age.

8.2 Emergency Electrical Power Systems

There are no emergency electrical power systems.

9. AUXILIARY SYSTEMS

9.1 Heating, Ventilation, and Air Conditioning Systems

A stack extends above the reactor room to 50 feet above ground level. It contains a CWS filter for removing the small amount of fission products that might evolve from a maximum credible accident. Air circulation occurs via natural circulation. Forced circulation ventilation is provided in all other rooms in the facility.

Temperature control in the facility is provided by an air conditioning system near the bathroom, and a small boiler house outside the maintenance hallway (which is located immediately outside the reactor room).

9.2 Handling and Storage of Reactor Fuel

Because the RCF reactor operates at such low power levels, it is reasonable to assume there is effectively no depletion in the fuel. Consequently, there are no spent fuel concerns; nor is there ever a need to bring more fuel into the facility. Nuclear material will not need to be removed from the RCF until the facility is decommissioned.

Individual fuel pins are occasionally added or removed from the core. Each fuel pin has a hole built into the top for ease of removal (see Figure 4.5). [redacted] It is remarkably well-suited for this purpose.

[redacted]

9.3 Fire Protection Systems and Programs

The fire detection and protection systems in the RCF meet state and local requirements. All walls in the facility are masonry. Fire extinguishers are located in the building and are checked at regular intervals.

9.4 Communication Systems

The RCF has a commercial phone line with phones in the control room and office. A cellular phone is also located in the office.

There is a battery-powered, 2-way wired intercom system between the control room and reactor room.

9.5 Possession and Use of Byproduct, Source, and Special Nuclear Material

Operation of the RCF reactor does not result in production of radioactive byproducts. There are no radioactive materials at the RCF that are used for reactor operation or experiments (other than the PuBe neutron source). There are several small calibration sources in the facility.

9.6 Cover Gas Control in Closed Primary Coolant Systems

This section does not apply to the RCF reactor.

9.7 Other Auxiliary Systems

There are no other auxiliary systems required for safe reactor operation.

10. EXPERIMENTAL FACILITIES AND UTILIZATION

There are currently no experimental facilities at the RCF.

Experiments commonly performed at the RCF are listed in Section 1.6 and do not require specific experimental facilities. For the [redacted] it would be possible to modify the spare control rod drive to raise and lower experiments into the center of the core, but there are currently no plans to do this. This system would operate like the control rod drives and would be limited by the maximum experiment reactivity worth of 60 cents found in Section 3.4 of the Technical Specifications.

All new experiments or classes of experiments that raise an unreviewed safety question shall be reviewed and approved by the Nuclear Safety Review Board in accordance with Section 6.3 of the Technical Specifications.

11. RADIATION PROTECTION PROGRAM AND WASTE MANAGEMENT

11.1 Radiation Protection

11.1.1 Radiation Sources

11.1.1.1 Airborne Radiation Sources

There are normally no airborne sources of radiation at the RCF. In the event of fuel pin clad rupture, the fission product inventory may be released but would be too small to pose a significant health risk.

11.1.1.2 Liquid Radioactive Sources

A small amount of radioactivity exists in the reactor tank water during operation, but this consists of short-lived isotopes and does not pose a health concern.

11.1.1.3 Solid Radioactive Sources

The reactor fuel constitutes a solid radioactive source; though other than short-lived fission product decay, the fuel does not present a significant health concern. In fact, in most cases the fuel can be safely handled minutes after reactor operation.

11.1.2 Radiation Protection Program

RPI has a structured radiation safety program with a staff equipped with radiation detection instrumentation to determine, control, and document occupational radiation exposures at its reactor facility. In addition, the critical facility monitors liquid effluents before release to comply with applicable guidelines and monitors for airborne activity within the reactor room to confirm that all effluents contain insignificant concentrations of radioactive materials.

11.1.3 ALARA Program

The university Provost, in the Radiation Safety Regulations and Procedures, has established formally the policy that operations are to be conducted in a manner to maintain all radiation exposure consistent with the ALARA principle. All proposed experiments and procedures at the reactor are reviewed for ways to decrease the potential exposure of personnel. All unanticipated or unusual reactor-related exposure will be investigated by the Office of Radiation and Nuclear Safety and the operations staff to develop methods to prevent recurrences.

11.1.4 Radiation Monitoring and Surveying

The area gamma monitoring system and air particulate monitor are described in Section 7.7. In addition, a radiation survey is performed in the reactor room as part of the pre-startup procedure when the reactor is to be operated.

The health physics staff participates in experiment planning by reviewing all proposed procedures for methods of minimizing personnel exposure and limiting the generation of radioactive waste. Approved procedures specify the type and degree of radiation safety support required by each activity.

11.1.5 Radiation Exposure Control and Dosimetry

The RPI personnel monitoring program is described in the Radiation Safety Regulations and Procedures Manual. To summarize the program, personnel exposures are measured by the use of thermoluminescent dosimeters (TLDs) assigned to individuals who might be exposed to radiation. In addition, instrument dose rate and time measurements are used to administratively keep occupational exposures well below the applicable limits in 10 CFR 20.

Staff TLDs are checked regularly and consistently show no measurable radiation exposure.

11.1.6 Contamination Control

Monthly contamination surveys are performed to ensure there is no contamination in the facility. These surveys routinely show that there is no detectable contamination.

11.1.7 Environmental Monitoring

The environmental monitoring program consists of several TLDs placed at the exclusion area boundary and at the site boundary. The results indicate about 5 mrem/yr at the site boundary and up to 15 mrem/yr at the exclusion area boundary above that measured at the General Electric Company Guard Station more than 1.6 km away.

11.2 Radioactive Waste Management

The RCF reactor produces insignificant quantities of radioactive waste during normal use because of both its low power level and its limited operating schedule, which are restricted by the Technical Specifications.

12. CONDUCT OF OPERATIONS

12.1 Organization

12.1.1 Structure

Responsibility for the safe operation of the reactor facility is vested within the chain of command shown in Figure 12.1.

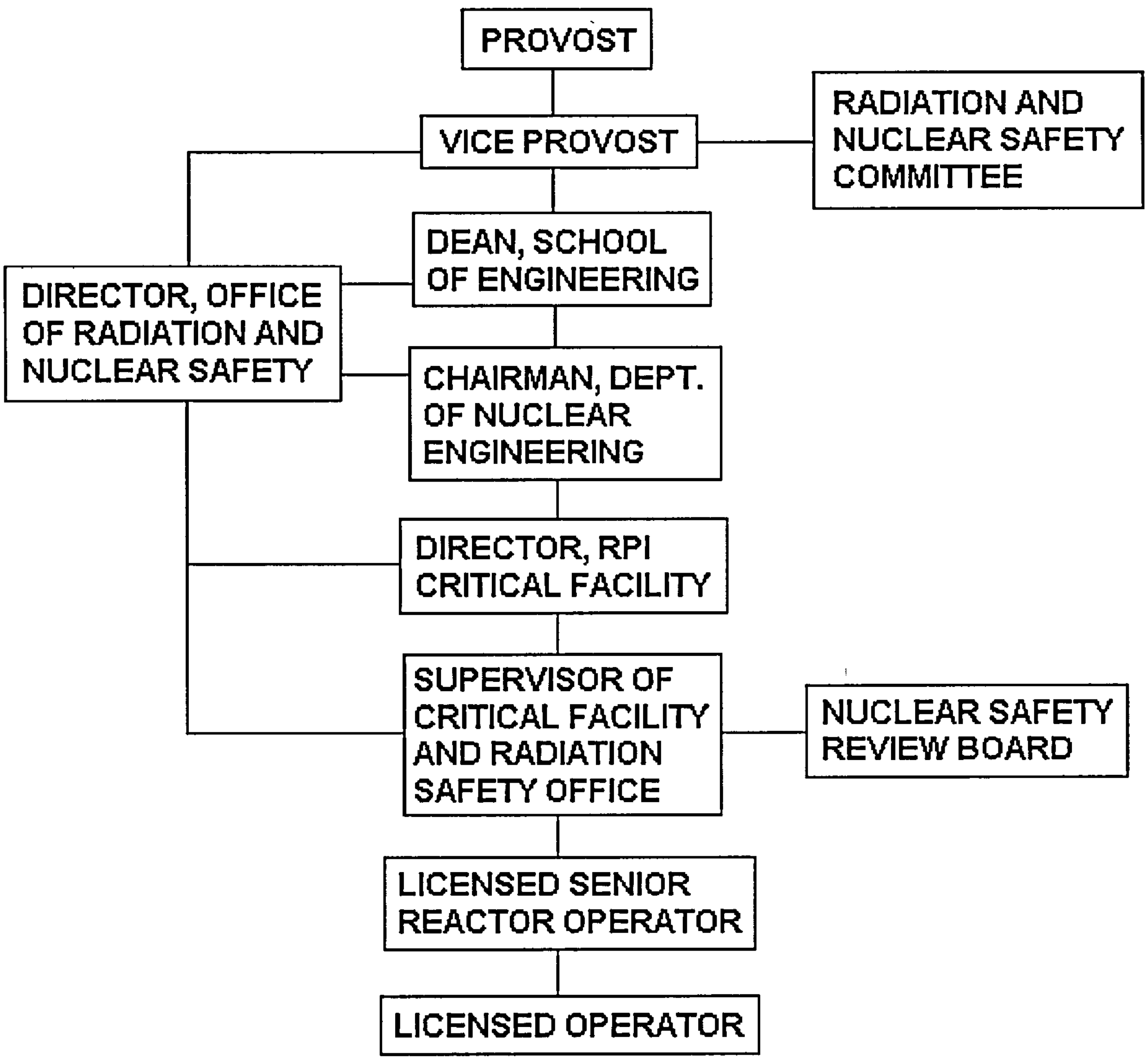


Figure 12.1: RCF Organization

12.1.2 Responsibility

The responsibilities of the individuals in Figure 12.1 are explained in Section 6.1 of the Technical Specifications.

12.1.3 Staffing

Staffing requirements are found in Section 6.1.3 of the Technical Specifications.

12.1.4 Selection and Training of Personnel

New reactor operators are selected from interested students enrolled in classes that take place at the RCF. Most of the training of reactor operators is done by existing RCF personnel. The Operator Requalification Program meets the regulations in 10 CFR 55. *The requalification program is included in the materials submitted for relicensing.*

12.1.5 Radiation Safety

Radiation safety aspects of facility operation are typically performed by members of the RCF staff, including routine radiation and contamination surveys and air sampling. Occasionally, some of these tasks are performed by a member of the campus radiation safety organization.

12.2 Review and Audit Activities

The Nuclear Safety Review Board (NSRB) provides independent review and audits facility activities. The Technical Specifications list the qualifications and provide that alternate members may be appointed by the NSRB Chairman. The NSRB meets at least semiannually. The board must review and approve plans for modifications to the reactor, new experiments, and proposed changes to the license or to procedures. The board also is responsible for conducting audits of reactor facility operations and management, and for reporting the results thereof to the RCF Director.

12.3 Procedures

Written operating procedures are used for the following:

- Reactor Pre-Startup
- Reactor Operations
- Surveillances
- Emergencies

The operating procedures are included in the materials submitted for relicensing.

12.4 Required Actions

Required actions to be taken in the event that a safety limit is exceeded or other reportable occurrence takes place are outlined in Section 6.5 of the Technical Specifications.

12.5 Reports

Reports will be made to the NRC in accordance with Section 6.6 of the Technical Specifications.

12.6 Records

Records for the RCF will be kept in accordance with Section 6.7 of the Technical Specifications.

12.7 Emergency Planning

10 CFR 50.54 requires that a licensee authorized to possess and/or operate a research reactor shall follow and maintain in effect an emergency plan that meets the requirements of Appendix E of 10 CFR 50. The Emergency Plan for the RCF currently in use is dated December 1984. *The Emergency Plan is included in the materials submitted for relicensing.*

The objective of the plan is to establish guidelines for responding to emergency conditions should a radiological emergency occur at the Critical Facility site that may affect the health and safety of workers or the general public.

The plan describes the Critical Facility emergency organization and includes the responsibilities and authority with a line of succession for key members of the emergency organization. The emergency organization described in the plan ensures that emergency management will be available to meet any foreseeable emergency at the research reactor. Additionally, the plan describes the criteria for the termination of an emergency, authorization for reentry, and establishes limits of exposure to radiation in excess of normal occupational limits for emergency team members for life saving and corrective actions to mitigate the consequences of an accident.

Two emergency classes are described for the Critical Facility. These classes are based upon credible accidents associated with the reactor operations and other emergency situations that are non-reactor related but could affect routine reactor operations. The emergency classes are Personnel Emergency and Emergency Alert. Each class is associated with specific Emergency Action Levels (EALs) for activating the emergency organization and initiating protective actions appropriate for the emergency event in process. The Emergency Planning Zone (EPZ) is the area within the Critical Facility building. Predetermined protective actions for the EPZ include radiation surveys to locate areas and levels of radioactive contamination, personnel evacuation should this become necessary and personnel accountability.

The emergency facilities and equipment available for emergency response include a designated Emergency Support Center, radiological monitoring systems, instruments and laboratory facilities for continually assessing the course of an accident, first aid and medical facilities and communications equipment. The provisions for maintaining emergency preparedness include programs for training, retraining, drills, plan review and updates, and equipment inventory and calibrations.

12.8 Security Planning

The RCF has established and maintains a program to protect the reactor and fuel and to ensure its security. The NRC staff has reviewed the Physical Security Plan submitted in 1983 and concluded that the plan met the requirements of 10 CFR 73.67 for special nuclear material of moderate strategic significance. Both the physical security plan and the staff's evaluation are withheld from public disclosure under 10 CFR 2.790(d)(1) and 10 CFR 9.5(a)(4). Amendment No. 4 to the facility Operating License CX-22, dated July 27, 1983, incorporated the Physical Security Plan as a condition of the license.

12.9 Quality Assurance

Quality Assurance is achieved via extensive documentation and periodic interaction with the Nuclear Safety Review Board (NSRB). All operations and experiments must follow written procedures that have been approved by the NSRB.

12.10 Operator Training and Requalification

Operator training and requalification programs are described in Section 12.1.4. *The requalification program is included in the materials submitted for relicensing.*

12.11 Startup Plan

A startup plan is not necessary for facility license renewal. The facility is not undergoing any changes that would require such a plan.

12.12 Environmental Reports

An environmental report is included in the materials submitted for relicensing. The facility has existed up to the present without having any significant effect on the environment. No future changes to the facility are anticipated that would result in an increased effect on the environment.

13. ACCIDENT ANALYSIS

13.1 Accident-Initiating Events and Scenarios

Several potentially serious accident scenarios have been evaluated and, even in the worst event sequence considered, no release of a significant quantity of radioactive fission products to the reactor cell would occur. Effects due to natural phenomena, mechanical rearrangement of the fuel, and reactivity insertion were all analyzed.

13.1.1 Maximum Hypothetical Accident

The potentially most severe accident at the RCF is due to reactivity insertion and, hence, this is the limiting case for design purposes. Hypothesizing that an unsecured experiment causes $0.60 reactivity to be instantaneously inserted while the reactor is operating at maximum power, the resultant excursion induces a negligible rise in fuel temperature. This scenario and the details of the analysis are discussed in the next section.

13.1.2 Insertion of Excess Reactivity

The most extreme scenario hypothesized consists of the worst reactivity excursion coincident with a single failure in the reactor protection system.

The worst reactivity excursion results from an unsecured experiment with a reactivity worth equal to the maximum excess reactivity allowed by the Technical Specifications of $0.60. Specifically, this could result from an experiment in which a strip of poison, such as boron, is placed in the core, the control rods pulled all the way out to obtain just critical conditions, thereupon the boron strip falls out of the core, resulting in a step reactivity insertion of the specified amount. A pre-accident power level of 200 watts is assumed, based upon the Technical Specification limit of 100 watts and incorporating a factor of two to account for the cumulative uncertainties associated with instrument calibration. For analytical purposes, the reactivity feedback effects of temperature and void formation are neglected so that control rod insertion is necessarily the terminating event.

The open circuit failure of the ion chamber serving log power and period channel 2 (PP2), coincident with the beginning of the accident, is also assumed. Because this one ion chamber supplies the input to the circuit that provides both the log power (135 watts) and the short period (5 seconds) scram, these scram relays are assumed to be disabled. The failure chosen, then, is the "worst case" single instrument malfunction. Remaining scram protection is provided only by the two linear power channels (LP1, LP2), each of which initiates a scram if its respective meter indication exceeds 90% of the selected scale. Commonly, the operator upscales these meters by factors of three as power increases during a directed power increase to preclude an inadvertent shutdown. For purposes of the accident scenario, LP1 and LP2 are assumed to indicate a value of 10% on the highest selectable scale at the onset of the accident, roughly correlating with 200 watts in-core power (100 watts indicated with factor of two uncertainty). Thus the power must increase by a factor of nine from this pre-accident level to prompt the linear power channel scram activation. Notably, because of the nature of the accident, its severity is not sensitive to variation in initial power. The single insertion of a fixed amount of positive reactivity quickly puts the reactor on a constant positive period, so that both the value of reactor power and its rate of increase when scram is initiated are unrelated to power levels immediately beforehand. Hence selection of a very low power, visible yet well below the point of adding heat, would not have aggravated the results of the analysis.

13.1.3 Loss of Coolant

Loss of coolant does not result in an accident situation at the RCF. In fact, the fast moderator dump is considered an alternate scram mechanism.

13.1.4 Loss of Coolant Flow

This does not apply to the RCF reactor.

13.1.5 Mishandling or Malfunction of Fuel

Mechanical rearrangement of the fuel to obtain a supercritical configuration, inadvertently or with intent, is not a credible occurrence. [redacted] In the unlikely event that sufficient force to break one or more of the fuel pins was developed, [redacted] would not cause a significant off-site hazard.

13.1.6 Experiment Malfunction

Experiments must be designed such that the maximum possible reactivity effect is 60 cents as limited by the Technical Specifications. Failure of an experiment with this reactivity worth is considered as a possible accident-initiating event and is described in Section 13.1.2.

13.1.7 Loss of Normal Electrical Power

Loss of normal electrical power will cause the reactor to shut down. This does not result in an accident situation.

13.1.8 External Events

Adequate protection against the potential effects of natural phenomena including fires, windstorms, floods, and earthquakes is provided. Radiological hazards to the public from these events are not significant.

[redacted] (similar to a fuel malfunction incident as described in Section 13.1.5).

13.1.9 Mishandling or Malfunction of Equipment

No equipment malfunction scenarios are envisioned that would result in a serious accident scenario.

13.2 Accident Analysis and Determination of Consequences

With the reactor operating initially at 200 watts, the insertion of \$0.60 positive reactivity causes power to promptly jump to 600 watts and then increase on a period of 3.0 seconds to 1800 watts, at which point LP1 and/or LP2 generate a scram signal. Allowing 1.5 seconds thereafter for the rods to be bottomed (Technical Specification is 900 msec), analysis conservatively assumes the instantaneous insertion of \$1.000 negative reactivity (less than the core shutdown margin) at 5 seconds after the excursion begins.

Maximum power reached during the transient is slightly below 3050 watts, depositing about 10 kJ of energy in the core and inducing a fuel temperature rise of less than 0.1°C above an initial value of 20°C. This energy deposition is roughly a factor of 10^3 less than the core safety limit identified in the Technical Specifications. Figure 13.1 portrays changes in power for the stated reactivity insertion transient, annotated with pertinent events. Clearly the integrity of the fuel is not in question. Additionally, while feedback effects are intentionally disregarded in the analysis, the very small temperature change encountered would make their cumulative effect negligible. This conclusion is valid for both the Core A and Core B pin arrangements.

The supporting transient analyses conducted employed the "FRKGB" computer code model[2], developed at RPI specifically for low power pool reactors. The model utilized Runge-Kutta time stepping methods to derive numerical solutions. The program was initially benchmarked against a set of Gaussian, Nordheim-Fuchs, and SPERT type bursts.

Tables 13.1 through 13.3 list pertinent nuclear and physical characteristics of the core configuration used in the analysis that are relevant to safe operations.

The core physics design and fuel vault criticality calculations were carried out using the LEOPARD[3] code with ENDF/B-4 based data) to compute few group diffusion constants, the PLATAB[4] code to compute equivalent few group diffusion constants for strong absorbers (this code used detailed flux spectra from LEOPARD), and the DIFXY[5] code to apply few group diffusion code theory in X-Y geometry.

Figures 13.2 and 13.3 display graphs of the temperature coefficient of reactivity for the solid (Core A) and annular (Core B) core fuel pin arrangements, respectively. The curves portray data derived from the computer codes referenced above.

13.3 Summary and Conclusions

The most severe hypothetical accident at the RCF involves a reactivity insertion transient. However, none of the accidents postulated would release significant fission products from the fuel. No credible accidents at the RCF pose a significant risk to public health and safety.

Table 13.1: Nuclear and Physical Characteristics of the RPI LEU Core

Effective Delayed Neutron Fraction,	$\beta_{eff} = 0.00765$
Effective Neutron Lifetime,	$l^* = 12.2 \times 10^{-6}$ sec

Delayed Neutron Data

Group No.	β_i/β_{eff}	Decay Constant[(1)]
1	0.041	3.01
2	0.115	1.14
3	0.396	0.301
4	0.196	0.111
5	0.219	0.0305
6	0.033	0.0124

Reactor Power,	P = 100 watts
Axial Power Shape	Chopped Sine
Coolant Temperature,	T = 20°C

(1) G.R. Keepin, "Physics of Nuclear Kinetics", Addison Wesley, 1965.

Table 13.2: Kinetics Parameters of RPI LEU Core and Technical Specifications

Kinetics Parameter	LEU Core Value	Technical Specification
Excess Reactivity at 68°F	0.00468	< 0.00468
Reactivity with One Stuck Rod	< -0.005	< -0.005
Shutdown Margin	> 0.02	> 0.02
Core Average Isothermal Temperature Coeff. Of Reactivity	< 0 for T > 91°F(1)	< 0 for T > 100°F
Core Average Void Coefficient of Reactivity(1)	$-9.99 \times 10^{-3}/cm^3$ at 57°F	$< -3.3 \times 10^{-6}/cm^3$
Integrated Reactivity Due to Temperature Change, 50°F-T(α_T=0)(1)	1.073×10^{-3}	$< 1.148 \times 10^{-3}$
Reactivity Worth of Standard Fuel Assembly(2)	< 0.039	< 0.039

(1) Value cited is for the Core B arrangement. Values for Core A are less restrictive.

(2) Note: A "standard fuel assembly" consists of a single fuel pin in the RPI LEU Core.

Table 13.3: Calculated Feedback Coefficients for RPI LEU Core

Core Average Void Coefficient of Reactivity = 0.7647 pcm/cm^3

Radial[1] Values of the Average Void Coefficient of Reactivity:

Distance from Core Center (cm)	Average Void Coefficient (pcm/cm^3)
0.00	-1.2795
2.97	-1.26078
5.94	-1.14822
8.92	-0.97842
11.89	-0.77206
14.86	-0.56474
17.83	-0.27250

(1) Values cited along a radial from the core center outward toward a control rod with symmetry assumed.

Isothermal Temperature Coefficient for LEU Core A:

$\alpha_T(°C) = 1.825x10^{-8}T^2 - 4.8x10^{-6}T + 6.932x10^{-5}$

and $\alpha_T < 0$ for $T < 16°C$ (61°F)

Isothermal Temperature Coefficient for LEU Core B:

$\alpha_T(°C) = 2.113x10^{-8}T^2 - 5.0x10^{-6}T + 1.423x10^{-4}$

and $\alpha_T < 0$ for $T < 32°C$ (91°F)

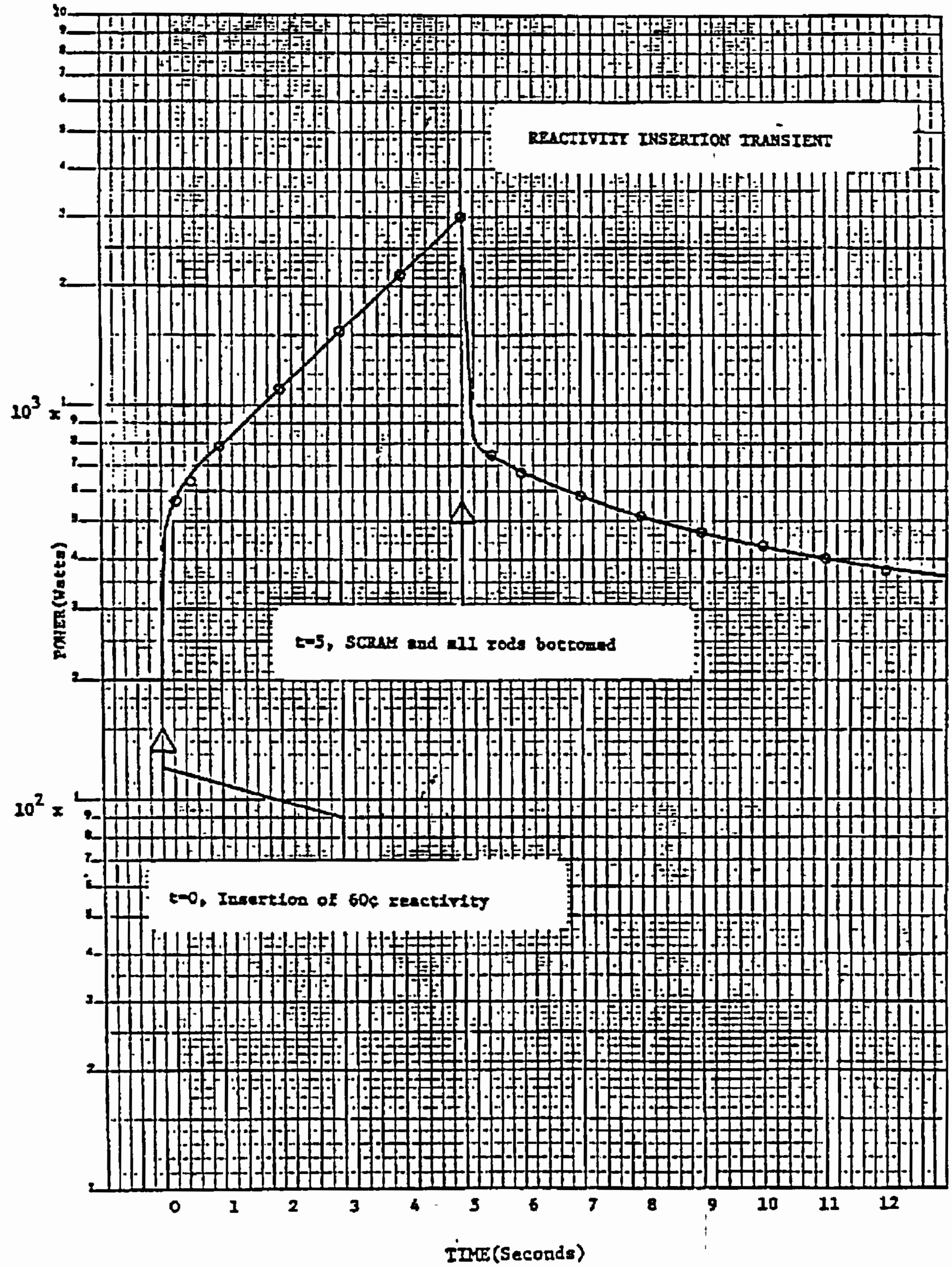


Figure 13.1: Reactivity Insertion Transient

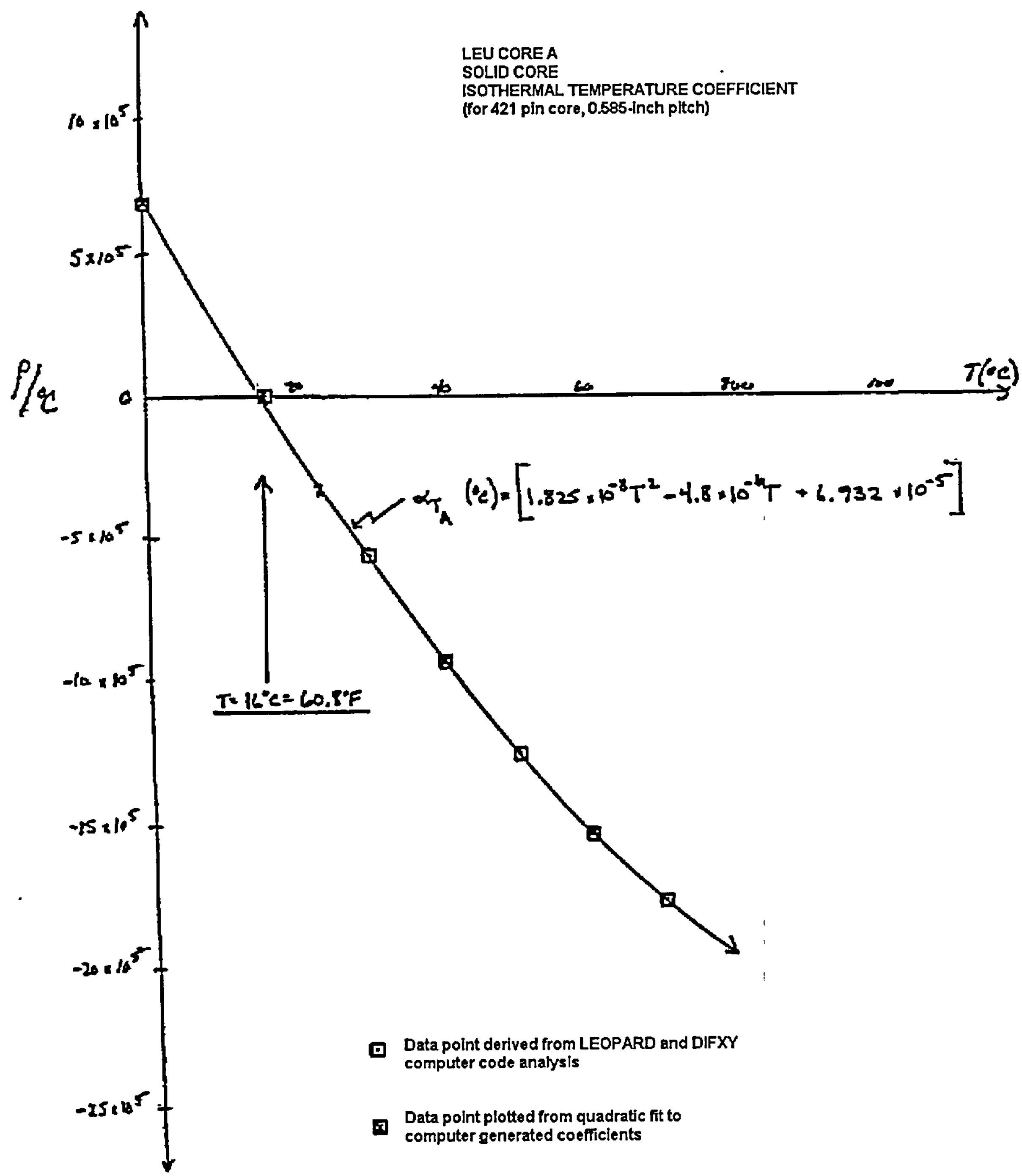


Figure 13.2: Core A, Isothermal Temperature Coefficient

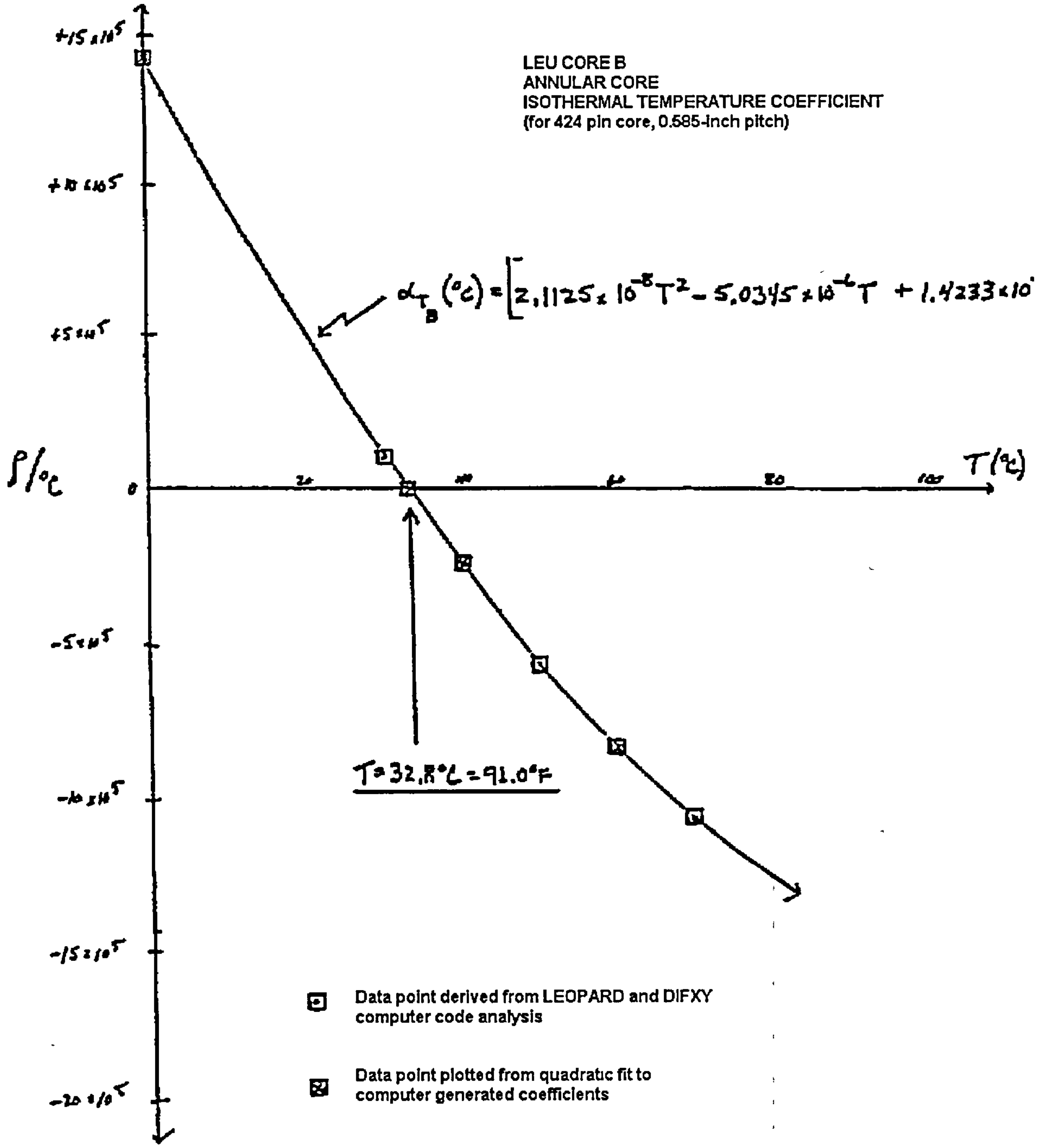


Figure 13.3: Core B, Isothermal Temperature Coefficient

13.4 References

1. D.R. Harris and F. Wicks, "Rensselaer Polytechnic Institute Critical Facility Safety Analysis Report." Docket No. 50-225. License No. CX-22. January 1983.

2. D.R. Harris, O.C. Jones, F.E. Wicks, A.B. Harris, F. Rodriguez-Vera, and C.F. Chuang, "Design Basis Transient Analysis for Low Power Research Reactors", Proc. Of Int. Symposium on Use and Development of Low and Medium Flux Research Reactors, Cambridge, Mass., Oct. 16-19, 1983, Atomkemenergie, Kerntechnik, 44, 450 (1983).

3. L.E. Strabridge and R.F. Barry, Nucl. Sci. and Eng., 23, 58 (1965).

4. D.R. Harris, "PLATAB, a Code for Computation of Equivalent Diffusion Theory Parameters for Strong Absorbers," Tech. Apl. Associates, TAA-1, 1986.

5. D.R. Harris, "DIFXY, a Multigroup Diffusion Code for X-Y Geometry," Tech. Apl. Associates, TAA-1, 1985.

6. P.E. MacDonald, R.K. McCardell, Z.R. Martinson, R.R. Hobbins, S.L. Seiffert, and B.A. Cook, "Light Water Reactor Fuel Response During Reactivity Initiated Accident Experiments", Proc. ANS Topical Meeting, Portland, Oregon (1979).

7. P.R. Nelson and D.R. Harris, "Reconfiguration of the RPI Critical Facility," Nucl. Tech., 60, 320 (1983).

14. TECHNICAL SPECIFICATIONS

The proposed Technical Specifications for the RCF reactor are attached as Appendix A to the SAR. They have been updated from the Technical Specifications currently in force (submitted in 1983) to reflect changes to the facility. The format remains essentially unchanged from the previous version.

Normal reactor operation within the limits of these Technical Specifications will not result in offsite exposures in excess of 10 CFR 20 limits. In addition, the limiting conditions for operation and surveillance requirements will limit reduce the probability of malfunctions and mitigate the consequences to the public of accident events.

15. FINANCIAL QUALIFICATIONS

15.1 Financial Ability to Construct a Non-Power Reactor

This section does not apply to the RCF relicensing process.

15.2 Financial Ability to Operate a Non-Power Reactor

The RCF has an exceptionally low annual budget; typically below $50,000. This number has been somewhat higher over the last few years due to the substantial equipment upgrades underway.

Total grants for fiscal year 2002 were $43,798, received entirely from DOE toward the facility equipment upgrades. RPI contributed an additional $20,000 for this purpose. Purchases for other equipment and supplies totaled $11,061. Gas and electric bills totaled $9,548.

Salaries for RCF personnel are included in the standard $50,000 annual budget. Currently, there are no full-time staff members at the facility.

With such low operating costs, it is not expected that funding for RCF operations will be a problem in the foreseeable future.

15.3 Financial Ability to Decommission the Facility

Decommissioning cost estimates vary depending upon the degree of work to be completed. If the only objective is to remove all fissionable material (i.e. the fuel) from the facility, decommissioning costs are estimated to be about $50,000. This relatively low cost does not pose a problem for the institute. A complete decommissioning, including removal of all hazardous waste and asbestos, and clean-up of the facility grounds (presumably contaminated from former ALCO plant operations), would cost at least 10 times that amount, or $500,000.

APPENDIX A: Proposed Technical Specifications

1. INTRODUCTION

1.1 Scope

The following constitutes the proposed Technical Specifications for the RPI Reactor Critical Facility, as required by 10 CFR 50.36.

1.2 Format

Content and section numbering are in accordance with section 1.2.2 of ANSI/ANS 15.1.

1.3 Definitions

The terms Safety Limit (SL), Limiting Safety System Setting (LSSS), and Limiting Condition for Operation (LCO), and Surveillance Requirements are as defined in 50.36 of 10 CFR Part 50.

A. Channel Calibration - The correlation of channel outputs to known input signals and other known parameters. Calibration shall encompass the entire channel, including equipment actuation, alarm, or trip.

B. Channel Check - Qualitative determination of acceptable operability by observation of instrument behavior during operation. This determination shall include, where possible, comparison of the instrument with other independent instruments measuring the same variable.

C. Channel Test - The injection of a simulated signal into the instrument primary sensor to verify the proper instrument response alarm and/or initiating action.

D. Control Rod Assembly - A control mechanism consisting of a stainless steel basket that houses two absorber sections, one above the other. These absorber sections contain enriched boron in iron. All absorber sections are clad in stainless steel. All are of the same dimensions, nominally 2.6 inches square, with their poisons uniformly distributed. The absorbers, when fully inserted, shall extend above the top and to within one inch of the bottom of the active core.

E. Excess Reactivity - The available reactivity above a cold, clean critical configuration which may be added by manipulation of controls.

F. Experiment - (1) An apparatus, device, or material placed in the reactor vessel, and/or (2) any operation designed to measure reactor characteristics.

G. Measuring Channel - The combination of sensor, lines, amplifiers, and output devices that are connected for the purpose of measuring the value of a process variable.

H. Measured Value - The value of the process variable as it appears on the output of a measuring channel.

I. Movable Experiment - A movable experiment is one in which material may be inserted, removed, or manipulated while the reactor is critical.

J. Operable - A system or component is capable of performing its intended function in its required manner.

K. Operating - A system or component is performing its intended function in its required manner.

L. Reactor Safety System - Combination of safety channels and associated circuitry that forms the automatic protective system for the reactor or provides information that requires manual protective action to be initiated.

M. Reactor Scram - A gravity drop of the control rods accompanied by the opening of the moderator dump valve. The scram can be initiated either manually or automatically by the safety system.

N. Reactor Secured - (1) The full insertion of all control rods has been verified, (2) the console key is removed, and (3) no operation is in progress that involves moving fuel pins in the reactor vessel, the insertion or removal of experiments from the reactor vessel, or control rod maintenance.

O. Reactor Shutdown - The control rods are fully inserted and the reactor is shutdown by at least 1.00$. The reactor is considered to be operating whenever this condition is not met and more than 60% of the total number of fuel pins required for criticality in a given configuration have been loaded in the core.

P. Readily Available on Call - The Licensed Senior Operator (LSO) on duty shall remain within a 30 mile radius or 60 minutes travel time of the facility, whichever is closer, and the operator-on-duty shall know the exact location and telephone number of the LSO on duty.

Q. Reportable Occurrence - The occurrence of any facility condition that:

   1. Causes a Limiting Safety System Setting to exceed the setting established in Section 2 of the Technical Specifications;

   2. Exceeds a Limiting Condition for Operations as established in Section 3 of the Technical Specifications;

3. Causes any uncontrolled or unplanned release of radioactive material from the restricted area of the facility;

4. Results in safety system component failures which could, or threaten to, render the system incapable of performing its intended safety function as defined in the Technical Specifications or SAR;

5. Results in abnormal degradation of one of the several boundaries which are designed to contain the radioactive materials resulting from the fission processes;

6. Results in uncontrolled or unanticipated changes in reactivity of greater than 0.60$.

7. Causes conditions arising from natural or offsite manmade events that affect or threaten to affect safe operation of the facility, or;

8. Results in observed inadequacies in the implementation of administrative or procedural controls such that the inadequacy causes or threatens to cause the existence or development of an unsafe condition in connection with the operation of the facility.

R. Review and Approve - The reviewing group or person shall carry out a review of the matter in question and may either approve or disapprove it; before it can be implemented, the matter in question must receive approval from the reviewing group or person.

S. Safety Channel - A measuring channel in the reactor safety system.

T. Secured Experiment - Any experiment, experimental facility, or component of an experiment is deemed to be secured, or in a secured position, if it is held in a stationary position relative to the reactor. The restraining forces must be equal to or greater than those that hold the fuel pins themselves in the reactor core.

U. Secured Shutdown - The reactor is secured and the facility administrative requirements are met for leaving the facility with no licensed operators present.

V. Shutdown Reactivity - The reactivity of the reactor at ambient conditions with all control rods fully inserted; including the reactivity of installed experiments.

W. Source - A neutron-emitting radioactive material, other than reactor fuel, which is positioned in or near the assembly to provide an external source of neutrons.

X. Surveillance Frequency - Unless otherwise stated in these specifications, periodic surveillance tests, checks, calibrations, and examinations shall be performed within the specified surveillance intervals. In cases where the elapsed interval has exceeded 100% of the specified interval, the next surveillance interval shall commence at the end of the original specified interval. Allowable surveillance intervals, as defined in ANSI/ANS 15.1 (1982) shall not exceed the following:

1. Five-year (interval not to exceed six years).

2. Two-year (interval not to exceed two and one-half years).

3. Annual (interval not to exceed 15 months).

4. Semiannual (interval not to exceed seven and one-half months).

5. Quarterly (interval not to exceed four months).

6. Monthly (interval not to exceed six weeks).

7. Weekly (interval not to exceed ten days).

8. Daily (must be done during the calendar day).

Y. Surveillance Interval - The surveillance interval is the calendar time between surveillance tests, checks, calibrations, and examinations to be performed upon an instrument or component when it is required to be operable.

Z. True Value - The actual value at any instant of a process variable.

AA. Unsecured Experiment - Any experiment, experimental facility, or component or an experiment is deemed to be unsecured if it is not and when it is not secured. Moving parts of experiments are deemed to be unsecured when they are in motion.

2. SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limits - Fuel Pellet Temperature

Applicability

Applies to the maximum temperature reached in any in-core fuel pellet as a result of either normal operation or transient effects.

Objective

To identify the maximum temperature beyond which material degradation of the fuel and/or its cladding is expected.

Specification

Fuel pellet temperature at any point in the core, resulting from normal operation or transient effects, shall be limited to no more than 2000°C.

Bases

Specific determination of the melting point of the SPERT fuel has not been reported. A safety limit of 2000°C is below the listed melting point of UO_2 under a wide variety of conditions. The chosen value is conservative in view of variations that might result due to the presence of small quantities of impurities and the comparatively high vapor pressure of UO_2 at elevated temperatures. The safety limit specified is about 700°C below the measured melting point of UO_2 in a helium atmosphere.

2.2 Limiting Safety System Settings - Reactor Power

Applicability

Applies to the settings to initiate protective action for instruments monitoring parameters associated with the reactor power limits.

Objective

To assure protective action before safety limits are exceeded.

Specification

The limiting safety system settings on reactor power shall be as follows:

Maximum Power Level	135 watts
Minimum Flux Level	2.0 counts/sec.
Minimum Period	5 seconds

Bases

The maximum power level trip setting of 135 watts on Log Power and Period Channel 2 (PP2) correlates with a reading of not greater than 90% on the highest scale of either of the two Linear Power Channels (LP1, LP2) as established by activation techniques. These scram setpoints ensure reactor shutdown and prevent significant energy deposition or enthalpy rise in the core in the event of any credible accident scenario.

The minimum flux level has been established at 2 cps to prevent a source-out startup and provide a positive indication of proper instrument function before any reactor startup.

The minimum 5-second period is specified so that the automatic safety system channels have sufficient time to respond in the event of a very rapid positive reactivity insertion. Power increase and energy deposition subsequent to scram initiation are thereby limited to well below the identified safety limit.

3. LIMITING CONDITIONS FOR OPERATION

3.1 Reactor Parameters

Applicability

These specifications apply to core parameters and reactivity coefficients.

Objective

The purpose of these specifications is to ensure that the reactor is operated within the range of parameters that have been analyzed.

Specifications

1. Above 100°F the isothermal temperature coefficient of reactivity shall be negative. The net positive reactivity insertion from the minimum operating temperature to the temperature at which the coefficient becomes negative shall be less than 0.15$.

2. The void coefficient of reactivity shall be negative, when the moderator temperature is above 100°F, within all standard fuel assemblies and have a minimum average negative value of 0.00043$/cc within the boundaries of the active fuel region.

3. The minimum operating temperature shall be 50°F.

Bases

The minimum absolute value of the temperature coefficient of reactivity is specified to ensure that negative reactivity is inserted when reactor temperature increases above 100°F. It is of note that even in the worst postulated accident scenarios, such as considered in Chapter 13 of the SAR, reactivity insertion because of temperature change would be negligible. The minimum average negative value of the void coefficient is specified to ensure that the negative reactivity inserted because of void formation is greater than that which was calculated in the SAR. The minimum operating temperature of 50°F establishes the temperature range for which the net positive reactivity limit can be applied.

3.2 Reactor Control and Safety Systems

Applicability

Applies to all methods of changing core reactivity available to the reactor operator.

Objective

To assure that available shutdown method is adequate and that positive reactivity insertion rates are within those analyzed in the Hazards Summary Report (hereinafter safety analysis report).

Specifications

1. The excess reactivity of the reactor core above cold, clean critical shall not be greater than 0.60$. The maximum reactivity worth of any clean fuel pin shall be 0.20$.

2. There shall be a minimum of four operable control rods. The reactor shall be subcritical by more than 0.70$ with the most reactive control rod fully withdrawn.

3. The maximum control rod reactivity rate shall be less than 0.12$/sec up to 10 times source level and 0.05$/sec at all higher levels.

4. The total control rod drop time for each control rod from its fully withdrawn position to its fully inserted position shall be less than or equal to 900 milliseconds. This time shall include a maximum magnet release time of 50 milliseconds.

5. The auxiliary reactor scram (moderator-reflector water dump) shall add negative reactivity within one minute of its activation.

6. The normal moderator-reflector water level shall be established not greater than 10 inches above the top grid of the core.

7. The minimum safety channels that shall be operating during the reactor operation are listed in Table 1.

8. After a scram, the moderator dump valve may be re-closed by a senior reactor operator if the cause of the scram is known, all control rods are verified to have scrammed and it is deemed wise to retain the moderator shielding in the reactor tank.

9. The interlocks that shall be operable during reactor operations are listed in Table 2.

10. The thermal power level shall be controlled so as not to exceed 100 watts, and the integrated thermal power for any consecutive 365 days shall not exceed 200 kilowatt-hours.

TABLE 1
Minimum Safety System Channels

Reactor Conditions - Ranges		Channels	Minimum Number	Functions
Start-up:	2 cps - 10^4 cps	Log Count Rate[a]	1	Minimum Flux Level
Power:	10^{-4} - 150%	Linear Power	2	High Neutron Level Scram
	10^{-3} - 300%	Log-N; Period[b]	1	High Neutron Level and Period Scram
		Manual Scram[c]	2	Reactor Scram
		Building Power	1	Loss of Power
		Reactor Door Scram[d]	1	Reactor Scram

(a)May be bypassed when linear power channels are reading greater than $3x10^{-10}$ amps.
(b)During steady-state operation, this safety channel may be bypassed with the permission of the Operations Supervisor.
(c)The manual scram shall consist of a regular manual scram at the console and a manual electric switch which shall disconnect the electrical power of the facility from the reactor, causing a loss of power scram.
(d)The reactor door scram may be bypassed during maintenance checks and radiation surveys with the specific permission of the Operations Supervisor provided that no other scram channels are bypassed.

TABLE 2
Interlocks

Interlocks	Action if Interlock Not Satisfied
Reactor Console Keys (2) "On"	Reactor Scram
Reactor Period 15 sec[a]	Prevents Control Rod Withdrawal
Neutron Flux 2 cps	Prevents Control Rod Withdrawal
Failure of 400 Cycle Synchro Power Supply	Prevents Control Rod Withdrawal
Failure of Line Voltage to Recorders	Prevents Control Rod Withdrawal
Moderator-Reflector Water Fill On	Prevents Control Rod Withdrawal

(a)These interlocks are available on only 1 of the 2 Log-N period Amplifiers and, therefore, may be bypassed with the permission of the Operations Supervisor if that one amplifier is out of service.

Bases

The minimum number of four control rods is specified to ensure that there is adequate shutdown capability even for the stuck control rod condition.

The insertion time of less than 900 milliseconds for each control rod from its fully withdrawn position is specified to ensure that the insertion time does not exceed that assumed when establishing the minimum period of Specification 2.2 as a limiting safety system setting.

The auxiliary reactor scram is specified to assure that there is a secondary mode of shutdown available during reactor operations. The requirement that negative reactivity be introduced in less than one minute following activation of the scram is established to minimize the consequences of any potential power transients.

The safety system channels listed in Table 1 provide a high degree of redundancy to assure that human or mechanical failures will not endanger the reactor facility or the general public.

The interlock system listed in Table 2 ensures that only authorized personnel can operate the reactor and the proper sequence of operations is performed. It also limits the actions that an operator can take, and assists him in safely operating the reactor.

Limitations imposed on core reactivity, control rod worth, and reactor power preclude conditions that could allow the development of a potentially damaging accident. The limitations are conservative in view of core energy deposition, yet permit adequate flexibility in the research and instruction for which the facility is intended.

3.3 Radiation Monitoring

Applicability

These specifications apply to the minimum radiation monitoring requirements for reactor operations.

Objective

The purpose of these specifications is to ensure that adequate monitoring is available to preclude undetected radiation hazards or uncontrolled release of radioactive material.

Specifications

1. The minimum complement of radiation monitoring equipment required to be operating for reactor operation shall include:

   a. A criticality detector system that monitors the main fuel storage area and also functions as an area monitor. This system shall have a visible and an audible alarm in the control room.

   b. An area gamma monitoring system that shall have detectors at least in the following locations: (1) control room; (2) reactor room near the fuel vault; (3) reactor room (high level monitor), and; (4) outside the reactor room window.

   c. Instruments to continuously sample and measure the particulate activity in the reactor room atmosphere shall be operating whenever the reactor is to be operated.

   d. The radiation monitors required by 3.3.1 a, b, and c, may be temporarily removed from service if replaced by an equivalent portable unit.

2. Portable detection and survey instruments shall be provided.

Bases

The continuous monitoring of radiation levels in the reactor room and other stations ensures the warning of the existence of any abnormally high radiation levels. The availability of instruments to measure the amount of particulate activity in the reactor room air ensures continued compliance with the requirements of 10 CFR Part 20. The availability of required portable monitors provides assurance that personnel will be able to monitor potential radiation fields before an area is entered.

In all cases, the low power levels encountered in operation of the critical assembly minimizes the probable existence of high radiation levels.

3.4 Experiments

Applicability

These specifications apply to all experiments placed in the reactor tank.

Objective

The objective of these specifications is to define a set of criteria for experiments to ensure the safety of the reactor and personnel.

Specifications

1. No new experiment shall be performed until a written procedure that has been developed to permit good understanding of the safety aspects is reviewed and approved by the Nuclear Safety Review Board and approved by the Operations Supervisor. Experiments that fall in the general category, but with minor deviations from those previously performed, may be approved directly by the Operations Supervisor.

2. No experiment shall be conducted if the associated experimental equipment could interfere with the control rod functions or with the safety functions of the nuclear instrumentation.

3. For movable experiments with an absolute worth greater than \$.35, the maximum reactivity change for withdrawal and insertion shall be \$.20/sec. Moving parts worth less than \$.35 may be oscillated at higher frequencies in the core.

4. The maximum positive step insertion of reactivity that can be caused by an experimental accident or experimental equipment failure of a movable or unsecured experiment shall not exceed \$.60.

5. Experiments shall not contain a material that may produce a violent chemical reaction and/or significant airborne radioactivity.

6. Experiments containing known explosives or highly flammable materials shall not be installed in the reactor.

7. All experiments that corrode easily and are in contact with the reactor coolant shall be encapsulated within corrosion resistant containers.

8. The radioactive material content of any singly encapsulated experiment shall be limited such that the complete release of all gaseous, particulate or volatile components directly to the reactor room will not result in exposures in excess of 10% of the equivalent annual exposures stated in 10 CFR 20 for persons

remaining in unrestricted areas for two hours or in restricted areas during the length of time required to evacuate the restricted area.

9. The radioactive material content of any doubly encapsulated experiment shall be limited such that the postulated complete release from the encapsulation or confining boundary of the experiment could not result in exposure in excess of applicable limits in 10 CFR 20 of any person occupying an unrestricted area continuously for a period of two hours from the time of release, or an exposure in excess of applicable limits in 10 CFR 20 for persons located within the restricted area during the length of time required to evacuate the restricted area.

Bases

The basic experiments to be performed in the reactor programs are described in the Safety Analysis Report (SAR). The present programs are oriented toward reactor operator training, the instruction of students, and with such research and development as is permitted under the terms of the facility license. To ensure that all experiments are well planned and evaluated prior to being performed, detailed written procedures for all new experiments must be reviewed by the NSRB and approved by the Operations Supervisor.

Since the control rods enter the core by gravity and are required by other technical specifications to be operable, no equipment should be allowed to interfere with their functions. To ensure that specified power limits are not exceeded, the nuclear instrumentation must be capable of accurately monitoring core parameters.

All new reactor experiments are reviewed and approved prior to their performance to ensure that the experimental techniques and procedures are safe and proper and that the hazards from possible accidents are minimal. A maximum reactivity change is established for the remote positioning of experimental samples and devices during reactor operations to ensure that the reactor controls are readily capable of controlling the reactor.

All experimental apparatus placed in the reactor must be properly secured. In consideration of potential accidents, the reactivity effect of movable apparatus must be limited to the maximum accidental step reactivity insertion analyzed. This corresponds to a 0.60$ positive step while operating at full power followed by one failure in the reactor safety system.

Restrictions on irradiations of explosives and highly flammable materials are imposed to minimize the possibility of explosion of fires in the vicinity of the reactor.

To minimize the possibility of exposing facility personnel or the public to radioactive materials, no experiment will be performed with materials that could result in a violent chemical reaction, produce airborne activity, or cause a corrosive attack on the fuel cladding or primary coolant system.

Specifications 8 and 9 will ensure that the quantities of radioactive materials contained in experiments will be so limited that their failure will not result in exposures to individuals in restricted or unrestricted areas to exceed the maximum allowable exposures stated in 10 CFR 20. The restricted area maximum is defined in 10 CFR 20.101 and 10 CFR 20.103. The unrestricted area maximum is defined in 10 CFR 20.105 and 10 CFR 20.106.

4. SURVEILLANCE REQUIREMENTS

4.1 Reactor Parameters

Applicability

These specifications apply to the verification of control rod reactivity worths, temperature and void coefficients of reactivity, and reactor power levels that pertain to reactor control.

Objective

The purpose of these specifications is to ensure that the analytical bases are and remain valid and that the reactor is safely operated.

Specifications

The following parameters shall be determined during the initial testing of an unknown or previously untested core configuration:

a. control rod back reactivity worth;

b. temperature and void coefficients of reactivity;

c. reactor power measurement;

d. shutdown margin.

Bases

Measurements of the above parameters are made when a new reactor configuration is assembled. Whenever the core configuration is altered to result in an unknown or untested configuration, the core parameters are evaluated to ensure that they are within the limits of these specifications and the values analyzed in the SAR. During the initial test period of the reactor, measurements and calculations of core parameters will be for standard assemblies that are to be utilized in the reactor's operational program.

4.2 Reactor Control and Safety

Applicability

These specifications apply to the surveillance of the safety and control apparatus and instrumentation of the facility.

Objective

The purpose of these specifications is to ensure that the safety and control equipment is operable and will function as required in Specification 3.2.

Specifications

1. The total control rod drop time and magnet release time shall be measured semiannually to verify that the requirements of Specification 3.2, Item 4, are met.

2. The moderator-reflector water dump time shall be measured semiannually to verify that the requirement of Specification 3.2, Item 5, is met.

3. All instrument channels, including safety system channels, shall be calibrated annually.

4. A channel test of the safety system channels (intermediate, and power range instruments) and a visual inspection of the reactor shall be performed daily prior to reactor startup. The interlock system shall be checked to satisfy rod drive permit. These systems shall be rechecked following a shutdown in excess of 8 hours.

5. The moderator-reflector water height shall be checked visually before reactor startup to verify that the requirements of Specification 3.2, Item 5, are met.

6. These tests may be waived when the instrument, component, or system is not required to be operable, but the instrument, component or system shall be tested prior to being declared operable.

Bases

Past performance of control rods and control rod drives and the moderator-reflector water fill and dump valve system have demonstrated that testing semiannually is adequate to ensure compliance with Specification 3.2, Items 3, 4, and 5.

Visual inspection of the reactor components, including the control rods, prior to each day's operation, is to ensure that the components have not been damaged and that the core is in the proper condition. Since redundancy of all safety channels is provided, random failures should not jeopardize the ability of the overall system to perform its required functions. The interlock system for the reactor is designed so that its failure places the system in a safe or non-operating condition. However, to ensure that failures in the safety channels and interlock system are detected as soon as possible, frequent surveillance is desirable and thus specified. All of the above procedures are enumerated in the daily startup checklist.

Past experience has indicated that, in conjunction with the daily check, calibration of the safety channels annually ensures the proper accuracy is maintained.

4.3 Radiation Monitoring

Applicability

These specifications apply to the surveillance of the area and air radiation monitoring equipment.

Objective

The purpose of these specifications is to ensure the continued validity of radiation protection standards in the facility.

Specification

The criticality detector system, area gamma monitors, and the mobile particulate air monitor shall be checked daily if the reactor is operated, tested monthly, and calibrated semiannually.

Bases

Experience has demonstrated that calibration of the criticality detectors, air gamma monitors, and the mobile air monitoring instrument semiannually is adequate to ensure that significant deterioration in accuracy does not occur. Furthermore, the operability of these radiation monitors is included in the daily pre-startup checklist.

5. DESIGN FEATURES

5.1 Site

The facility is located on a site situated on the south bank of the Mohawk River in the City of Schenectady. An inner fence of greater than 30 feet radius defines the restricted area. An outer fence and riverbank of greater than 50 feet radius defines the exclusion area.

5.2 Facility

The facility is housed in the reactor building. The security of the facility is maintained by the use of two fences; one at the site boundary and the other defining the restricted area around the reactor building itself.

5.3 Reactor Room

The reactor room is a 12-inch reinforced concrete enclosure with approximate floor dimensions of 40x30 feet. The height from the ground floor to the ceiling shall be about 30 feet. The roof is a steel deck covered by 2 inches of lightweight concrete, five plies of felt and asphalt, with a gravel surface. Access to the reactor room is through a sliding fireproof steel door that also contains a smaller personnel door. Near the center of the room is a pit 14.5 x 19.5 feet wide and 12 feet deep with a floor of 18-inch concrete. This part contains the 3500 gallon water storage tank and other piping and auxiliary equipment.

5.4 Reactor

5.4.1 Reactor Tank

The stainless steel lined reactor tank has a capacity of approximately 2000 gallons of water. The tank nominal dimensions are 7 feet in diameter and 7 feet high. The tank is supported at floor level above the reactor room by 8-inch steel I-beams. There are no side penetrations in the reactor tank.

The reactor tank is connected to the water storage tank via a six-inch quick dump line. Therefore, it is required that the storage tank be vented to the atmosphere such that its freeboard volume can always contain all water in the primary system.

5.4.2 Reactor Core

The reactor core shall consist of uranium fuel in the form of 4.81 weight percent or less enriched UO_2 pellets in metal cladding, arranged in roughly a cylindrical fashion with four control rods placed symmetrically about the core periphery. The total core configuration and the arrangement of individual fuel pins, including any experiment, shall comply with the requirements of these Technical Specifications found in Sections 3.1 and 3.2 of this license. The core shall consist of all SPERT (F-1) fuel described in (5.4.3) or approximately half of SPERT (F-1) fuel with the remainder (experiment) being made up of low enriched (4.81 w/o) uranium light water reactor type fuel of typical power reactor design and arrangement.

The fuel pins are supported and positioned on a fuel pin support plate, drilled with holes to accept tips on the end of each pin. The support plate rests on a carrier plate, which forms the base of a three-tiered overall core support structure. An upper fuel lattice plate rests on the top plate, and both are drilled through with holes with the prescribed arrangement to accommodate the upper ends of the fuel pins. The lower fuel pin support plate, a middle plate, and the upper fuel pin lattice plate are secured with tie rods and bolts. The entire core structure is supported vertically and anchored by four posts set in the floor of the reactor tank.

5.4.3 Fuel Pins

Core fuel pins to be utilized are 4.81 weight percent enriched SPERT (F-1) fuel rods. Each fuel rod is made up of sintered UO_2 pellets, encased in a stainless steel tube, capped on both ends with a stainless steel cap and held in place with a chromium nickel spring. Gas gaps to accommodate fuel expansion are also provided at both the upper end and around the fuel pellets. Figure 4.5 of the SAR depicts a single fuel pin and its pertinent dimensions.

Any fuel pins used in an experiment shall consist of uranium fuel in the form of 4.81 weight percent or less enriched UO_2 pellets encapsulated in metal cladding.

5.4.4 Control Rod Assemblies

Four control rod assemblies are installed, spaced 90 degrees apart at the core periphery. Each rod consists of a 6.99-cm square stainless steel tube, which passes through the core and rests on a hydraulic buffer on the bottom carrier plate of the support structure.

Housed in each of these "baskets" are two neutron-absorber sections, on positioned above the other as depicted in Figure 4.6 of the SAR. The combination of the four rods must meet the values given in Table 13.2 of the SAR, with regard to reactivity with one stuck rod and shutdown margin.

5.5 Water Handling System

The water handling system allows remote filling and emptying of the reactor tank. It provides for a water dump by means of a fail safe butterfly-type gate valve when a reactor scram is initiated. The filling system shall be controlled by the operator, who must satisfy the sequential interlock system before adding water to the tank. A pump is provided to add the moderator-reflector water from the storage dump tank into the reactor tank. A fast fill rate of about 50 gpm is provided. A nominal six-inch valve is installed in the dump line and has the capability of emptying the reactor tank on demand of the operator or when a reactor scram is initiated, unless bypassed with the approval of the licensed senior operator on duty. A valve is installed in the bottom drain line of the reactor tank to provide for completely emptying the reactor tank.

5.6 Fuel Storage and Transfer

When not in use, the SPERT (F-1) fuel shall be stored within the storage vault located in the reactor room. The vault shall be closed by a locked door and shall be provided with a criticality monitor near the vault door. The fuel shall be stored in cadmium clad steel tubes with no more than 1 kg fuel per tube mounted on a steel wall rack. A storage tube in the storage vault cannot contain more than 15 SPERT (F-1) fuel pins at any time. The center-to-center spacing of the storage tubes, together with the cadmium clad steel tubes, ensures that the infinite multiplication factor is less than 0.9 when flooded with water.

Experimental fuel, when not in use, shall be stored in an approved sealed shipping container in the reactor room. Criticality and radiation analyses shall have been performed for this fuel in the shipping containers before delivery.

All fuel transfers shall be conducted under the direction of a licensed senior operator.

Operating personnel shall be familiar with health physics procedures and monitoring techniques, and shall monitor the operation with appropriate radiation instrumentation.

For a completely unknown or untested system, fuel loading shall follow the inverse multiplication approach to criticality and, thereafter, meet Specification 4.2. Should any interruption of the loading occur (more than four days), all fuel elements except the initial loading step shall be removed from the core in reverse sequence and the operation repeated.

For a known system, up to a quadrant of fuel pins may be removed from the core or a single stationary fuel pin be replaced with another stationary pin only under the following conditions:

1. The net change in reactivity has been previously determined by measurement or calculation to be negative or less than 0.20$.

2. The reactor is subcritical by at least 1.00$ in reactivity.

3. There is initially only one vacant position within the active fuel lattice.

4. The nuclear instrumentation is one scale and the dump valve is not bypassed.

5. The critical rod bank position is checked after the operation is complete.

6. ADMINISTRATIVE CONTROLS

6.1 Organization

6.1.1 Structure

The organization for the management and operation of the reactor facility shall include the structure indicated in Figure A.1.

Level 1: The Facility Director is responsible for the facility license and site administration.

Level 2: The Operations Supervisor is responsible for the reactor facility operation and management.

Level 3: Licensed senior operators are responsible for daily reactor operations.

Level 4: Licensed operators are the operating staff.

A health physicist who is organizationally independent of RPI operations group shall provide advice as required by the RPI Operations Supervisor in matters concerning radiological safety. The health physicist also has interdiction responsibility and authority.

6.1.2 Responsibility

The Operations Supervisor of the Rensselaer Polytechnic Institute Critical Experiment Facility shall be responsible for the safe operation of the facility. He shall be responsible for ensuring that all operations are conducted in a safe manner and within the limits prescribed by the facility license, including these technical specifications.

In all matters pertaining to the operation of the reactor and these technical specifications, the Operations Supervisor shall report to and be directly responsible to the Facility Director.

6.1.3 Staffing

(a) The minimal staffing when the reactor is not shutdown as described in these specifications shall be:

1) An operator or senior operator licensed pursuant to 10 CFR 55 be present at the controls.

2) One other person in the control room certified by the Reactor Supervisor as qualified to activate manual scram and initiate emergency procedures.

This person is not required if an operator and a senior operator are in the control room.

3) A licensed senior operator shall be present or readily available on call.

4) The identity of and method for rapidly contacting the licensed senior operator on duty shall be known to the operator.

(b) A list of reactor facility personnel by name and telephone number shall be readily available in the control room for use by the operator. The list must include:

1) Management personnel.

2) Radiation safety personnel.

3) Other operations personnel.

(c) Events requiring the direction of the Operations Supervisor:

1) All fuel or control rod relocations within the reactor core.

2) Recovery from unplanned or unscheduled shutdown.

6.1.4 Selection and Training of Personnel

The selection, training and requalification of operations personnel shall meet or exceed the requirements of American National Standard for Selection and Training of Personnel for Research Reactors, ANSI/ANS-15.4-1977, Sections 4-6.

Additionally, the minimum requirements for the Operations Supervisor are at least four years of reactor operating experience and possession of a Senior Operator License for the RPI Critical Facility. Years spent in baccalaureate or graduate study may be substituted for operating experience on a one-for-one basis up to a maximum of two years.

6.2 Review and Audit

A Nuclear Safety Review Board (NSRB) shall review and audit reactor operations and advise the Facility Director in matters relating to the health and safety of the public and the safety of facility operations.

6.2.1 Composition and Qualification

The NSRB shall have at least four members of whom no more than the minority shall be from the line organization shown in Figure A.1. The board shall be made up of senior personnel who shall collectively provide a broad spectrum of expertise in reactor technology. Qualified and approved alternates may serve in the absence of regular members.

6.2.2 Charter and Rules

The Review Board shall function under the following rules:

(a) The Chairman of the NSRB shall be approved by the Facility Director.

(b) The Board shall meet at least semiannually.

(c) The quorum shall consist of not less than a majority of the full Board and shall include the Chairman or his designated alternate.

(d) Minutes of each Board meeting shall be distributed to the Director, NSRB members, and such others as the Chairman may designate.

6.2.3 Review and Approval Function

The following items shall be reviewed and approved before implementation:

(a) Proposed experiments and tests utilizing the reactor facility that are significantly different from tests and experiments previously performed at the facility.

(b) Reportable occurrences.

(c) Proposed changes to the Technical Specifications and proposed amendments to facility license.

6.2.4 Audit Function

(a) The audit function shall include selective (but comprehensive) examination of operating records, logs, and other documents. Where necessary, discussions with cognizant personnel shall take place. In no case shall the individual immediately responsible for the area audit in the area. The following areas shall be audited at least annually.

(b) Reactor operations and reactor operational records for compliance with internal rules, regulations, procedures, and with licensed provisions;

(c) Existing operating procedures for adequacy and to ensure that they achieve their intended purpose in light of any changes since their implementation;

(d) Plant equipment performance with particular attention to operating anomalies, abnormal occurrences, and the steps taken to identify and correct their use.

6.3 Procedures

Written procedures shall be prepared, reviewed and approved prior to initiating any of the activities listed in this section. The procedures, including applicable check lists, shall be reviewed by the NSRB and followed for the following operations:

1) Startup, operation and shutdown of the reactor.

2) Installation and removal of fuel pins, control rods, experiments, and experimental facilities.

3) Corrective actions to be taken to correct specific and foreseen malfunctions such as for power failures, reactor scrams, radiation emergency, responses to alarms, moderator leaks and abnormal reactivity changes.

4) Periodic surveillance of reactor instrumentation and safety systems, area monitors, and continuous air monitors.

5) Implementation of the facility security plan.

6) Implementation of facility emergency plan in accordance with 10 CFR 50, Appendix E.

7) Maintenance procedures that could have an effect on reactor safety.

Substantive changes to the above procedures shall be made only with the prior approval of the NSRB. Temporary changes to the procedures that do not change their original intent may be made with the approval of the Operations Supervisor. All such temporary changes to the procedures shall be documented and subsequently reviewed by the Nuclear Safety Review Board.

6.4 Experiment Review and Approval

1) All new experiments or classes of experiments that might involve an unreviewed safety question shall be reviewed by the Nuclear Safety Review Board. NSRB approval shall ensure that compliance with the requirements of the license technical specifications shall be documented.

2) Substantive changes to previously approved experiments shall be made only after review and approval in writing by NSRB. Minor changes that do not significantly alter the experiment may be approved by the Operations Supervisor.

3) Approved experiments shall be carried out in accordance with established approved procedures.

4) Prior to review, an experiment plan or proposal shall be prepared describing the experiment, including any safety considerations.

5) Review comments of the NSRB setting forth any conditions and/or limitations shall be documented in committee minutes and submitted to the Facility Director.

6.5 Required Actions

6.5.1 Action to be taken in Case of Safety Limit Violations

(a) The reactor shall be shutdown, and reactor operations shall not be resumed until authorized by the Nuclear Regulatory Commission.

(b) The safety limit violation shall be promptly reported to the level one authority or designated alternates and to the NSRB.

(c) The safety limit violation shall be reported to the Nuclear Regulatory Commission in accordance with Section 6.5.3.

(d) A safety limit violation report shall be prepared. The report shall describe the following:

1) Applicable circumstances leading to the violation, including, when known, the cause and contribution factors.

2) Effect of the violation upon reactor facility components, systems, or structures and on the health and safety of personnel and public.

3) Corrective action to be taken to prevent recurrence.

The report shall be reviewed by the NSRB and any follow-up report shall be submitted to the Commission when authorization is sought to resume operation of the reactor.

6.5.2 Action to be Taken in the Event of an Occurrence of the Type Identified in Section 1.0 Q (Reportable Occurrence)

(a) Reactor conditions shall be returned to normal or the reactor shall be shut down. If it is necessary to shut down the reactor to correct the occurrence, operations shall not be resumed unless authorized by the Facility Director or designated alternate.

(b) Occurrence shall be reported to the Facility Director or designated alternates and to the Commission as required.

(c) All such conditions, including action taken to prevent or reduce the probability of a recurrence, shall be reviewed by the NSRB.

6.6 Reports

In addition to the requirements of applicable regulations, and in no way substituting therefore, all written reports shall be sent to the U.S. Nuclear Regulatory Commission, Attn: Document Control Desk, Washington, D.C. 20555, with a copy to the Region I Administrator.

6.6.1 Operating Reports

A written report covering the previous year shall be submitted by March 1 of each year. It shall include the following:

(a) Operations Summary. A summary of operating experience occurring during the reporting period that relates to the safe operation of the facility, including:

1) Changes in facility design;

2) Performance characteristics (e.g., equipment and fuel performance);

3) Changes in operating procedures that relate to the safety of facility operations;

4) Results of surveillance tests and inspections required by these Technical Specifications;

5) A brief summary of those changes, tests, and experiments that require authorization from the Commission pursuant to 10 CFR 50.59(a), and;

6) Changes in the plant operating staff serving in the following positions:

a) Facility Director;

b) Operations Supervisor;

c) Health Physicist;

d) Nuclear Safety Review Board Members.

(b) Power Generation. A tabulation of the integrated thermal power during the reporting period.

(c) Shutdowns. A listing of unscheduled shutdowns that have occurred during the reporting period, tabulated according to cause, and a brief description of the preventive action taken to prevent recurrence.

(d) Maintenance. A tabulation of corrective maintenance (excluding preventative maintenance) performed during the reporting period on safety related systems and components.

(e) Changes, Tests and Experiments. A brief description and a summary of the safety evaluation for all changes, tests, and experiments that were carried out without prior Commission approval pursuant to the requirements of 10 CFR Part 50.59(b).

(f) A summary of the nature, amount and maximum concentrations of radioactive effluents released or discharged to the environs beyond the effective control of the licensee as measured at or prior to the point of such release or discharge.

(g) Radioactive Monitoring. A summary of the TLD dose rates taken at the exclusion area boundary and the site boundary during the reporting period.

(h) Occupational Personnel Radiation Exposure. A summary of radiation exposures greater than 25% of the values allowed by 10 CFR 20 received during the reporting period by facility personnel (faculty, students or experimenters).

6.6.2 Non-Routine Reports

(a) Reportable Operational Occurrence Reports. Notification shall be made within 24 hours by telephone and e-mail to the Administrator of Region I, followed by a written report within 10 days in the event of a reportable operational occurrence as defined in Section 1.0. The written report on these reportable operational occurrences, and to the extent possible, the preliminary telephone and e-mail notification shall: (1) describe, analyze, and evaluate safety implications; (2) outline the measures taken to ensure that the cause of the condition is determined; (3) indicate the corrective action (including any changes made to the procedures and to the quality assurance program) taken to prevent repetition of the occurrence and of similar occurrences involving similar components or systems; and (4) evaluate the safety implications of the incident in light of the cumulative experience obtained from the record of previous failures and malfunctions of similar systems and components.

(b) Unusual events. A written report shall be forwarded within 30 days to the Administrator of Region I in the event of: (1) Discovery of any substantial errors in the transient or accident analyses or in the methods used for such analyses, as described in the Safety Analysis Report or in the bases for the Technical Specifications.

6.7 Operating Records

6.7.1 The following records and logs shall be maintained at the Facility or at Rensselaer for at least five years.

(a) Normal facility operation and maintenance.

(b) Reportable operational occurrences.

(c) Tests, checks, and measurements documenting compliance with surveillance requirements.

(d) Records of experiments performed.

(e) Records of radioactive shipments.

6.7.2 The following records and logs shall be maintained at the Facility or at Rensselaer for the life of the Facility.

(a) Gaseous and liquid radioactive releases from the facility.

(b) TLD environmental monitoring systems.

(c) Radiation exposures for all RPI Critical Facility personnel (students and experimenters).

(d) Fuel inventories, offsite transfers and in-house transfers if they are not returned to their original core or vault location during the experimental program in which the original transfer was made.

(e) Facility radiation and contamination surveys.

(f) The present as-built facility drawings and new updated or corrected versions.

(g) Minutes of Nuclear Safety Review Board meetings.

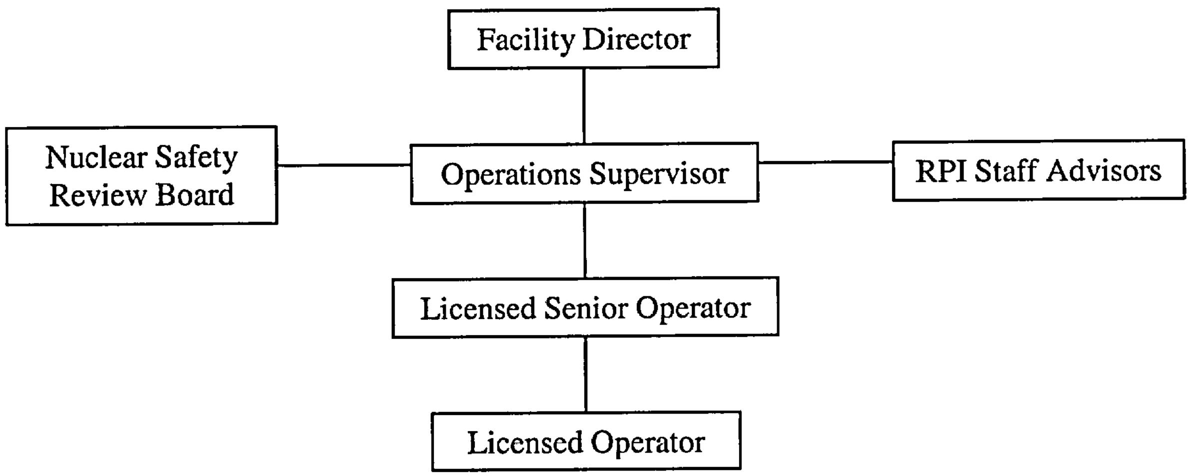


Figure A.1: RCF Management Organization