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Hot Cell Manipulator Inventory and Recommendations

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OAK RIDGE National Laboratory

ORNL IS MANAGED BY UT-BATTELLE LLC FOR THE US DEPARTMENT OF ENERGY

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Radioisotope Science and Technology Division

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1. BACKGROUND

During the spring of 2021 repeated manipulator failures in the hot cells of Building 7920 contributed to significant delays in Californium-252 (^{252}Cf) mission execution and loss of rapidly decaying ^{252}Cf product. At the same time, funds became available in the ^{252}Cf program budget for equipment purchases and upgrades. Accordingly, the ^{252}Cf program manager requested (1) an inventory of the manipulators used in six Oak Ridge National Laboratory (ORNL) buildings (7920, 7930, 4501, 3047, 3025E, and 3525), (2) an inventory of spare manipulators, and (3) a recommendation on whether to invest ^{252}Cf funds to purchase additional or upgraded manipulators.

2. MANIPULATOR INVENTORY

Manipulators are manufactured in many different models and are provided by a limited number of vendors. Each manipulator is designed or selected based on the type of work it is intended to accomplish and the location it will be used. Thus, even models with the same name (e.g., Model E) may not be the same in different buildings. Functioning and spare manipulators are specific to the building for which they were designed or selected. Inventory information was obtained during the spring and summer of 2021 and may be seen in Appendices A and B.

3. DISCUSSION

The six ORNL buildings included in this analysis have a total of 125 in-use (i.e., installed) manipulators and 13 complete spares, plus some additional spare internal and external arms. However, spares are specific to the building and function for which they were designed or selected. Preventative maintenance is not generally performed, and manipulators are used until failure. Malfunctions in manipulators can sometimes be addressed in place, but sometimes malfunctions require removal from the hot cell to repair.

ORNL has a dedicated manipulator repair team and maintenance shop with two bays that can each maintain one manipulator at a time. The shop contains a significant inventory of spare parts. ORNL also has a boot shop, where new boots (the plastic casing around a manipulator) are fabricated. The shop has poor atmospheric control, which may affect the quality of the boots produced. **Approximately one-third of manipulator failures are boot failures.**

Operator training is another factor affecting manipulator and boot failures, with improper usage of manipulators increasing the risk of breakage.

Spare manipulators limit programmatic downtime because they can be installed and used while the broken manipulator is repaired. However, spare manipulators take up valuable space. Some manipulators are used heavily, while others are used only occasionally. Additionally, the various programs using the manipulators have differing sensitivities to programmatic downtime due to manipulator malfunctions.

4. RECOMMENDATIONS

1. **Record and track data** related to manipulator installation, usage, time to failure, failure mode, time to repair, and whether a spare was available.

2. **Implement a preventative maintenance program.** Subject matter experts should be consulted, or a study should be performed to determine what fraction of manipulator failures could be avoided by a

preventative maintenance program. A cost/benefit analysis could then be performed to determine if a preventative maintenance program is of value.

3. **Consider purchasing additional spare manipulators to guard against high-consequence failures.** Every critical, time-sensitive operation should have at least one or two complete spare manipulators for immediate use in the event of a high-consequence failure. Manipulators cost approximately $150,000–$200,000 each. **Execution of this recommendation will require identifying, repurposing, or obtaining space to store the additional spare manipulators.**

4. **Invest in upgrades to the boot shop.** Installation of a more robust HVAC system and improvements to thermal insulation are underway, and additional upgrades to improve atmospheric control in the building should be considered.

5. **Ensure lessons learned from manipulator failures are integrated into the training curriculum for new operators.** This would highlight practices to avoid that have detrimental effects on manipulator health.

6. **Evaluate performance of newly purchased manipulators against existing manipulators.** Four new Walischmiller manipulators are in use in Building 3525, and ten more are currently being installed in Building 2026 for Isotek. Performance of these manipulators should be tracked and compared to performance of the currently in-use manipulators. If the new manipulators perform better and have fewer failures, a schedule for replacing existing manipulators with new manipulators could be proposed.

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APPENDIX A. SUMMARY OF MANIPULATOR INVENTORY

Location	Type	In-use	Spare(s)
BUILDING 7920	Model F	11	3
	Model E	4	1
	Model 8	3	2
	Model G	6	1
	Model D	2	1
BUILDING 7930	Model E	11	1
	Model E/F	1	—
	Modified Model D	2	—
	Model A	4	—
BUILDING 4501	Model E	8	1
BUILDING 3047	Model 8	6	1
	Model E	2	—
BUILDING 3025E	Model 8	13	2
	Model E	2	—
	Model G	2	—
	Model 4	1	—
BUILDING 3525	Model A	27	4 Ext. Arms 6 Int. Arms
	Model E	4	—
	Model 7	4	—
	Model G	2	—
	Model E/F	2	—
	Model D	1	—
	Model A100	2	—
	Model A110	2	—
	Model 300	2	—
	PAR	1	—

APPENDIX B. DETAILED IN-USE MANIPULATOR INVENTORY

BUILDING 7920

Building	Hot Cell	Location	Model	Duty
7920	1	Left	CRL Model F	Heavy
7920	1	Right	CRL Model E	Heavy
7920	2	Left	CRL Model F	Heavy
7920	2	Right	CRL Model E	Heavy
7920	3	Left	CRL Model E	Heavy
7920	3	Right	CRL Model F	Heavy
7920	4	Left	CRL Model F	Heavy
7920	4	Right	CRL Model F	Heavy
7920	5	Left	CRL Model E	Heavy
7920	5	Right	CRL Model F	Heavy
7920	6	Left	CRL Model F	Heavy
7920	6	Right	CRL Model F	Heavy
7920	7	Left	CRL Model F	Heavy
7920	7	Right	CRL Model F	Heavy
7920	8	Left	AMF Model 8	Heavy
7920	8	Right	AMF Model 8	Heavy
7920	9	Left	CRL Model 8	Heavy
7920	9	Right	CRL Model F	Heavy
7920	10	Left	CRL Model D	Intermediate
7920	10	Right	CRL Model D	Intermediate
7920	Cave A	Left	CRL Model G	Light
7920	Cave A	Right	CRL Model G	Light
7920	Cave B	Left	CRL Model G	Light
7920	Cave B	Right	CRL Model G	Light
7920	TDF	Left	CRL Model G	Light
7920	TDF	Right	CRL Model G	Light

BUILDING 7930

Building	Hot Cell	Workstation	Location	Model
7930	Cell G	WS #1	Left	CRL Model E
7930	Cell G	WS #1	Right	CRL Model E
7930	Cell G	WS #2	Left	CRL Model E
7930	Cell G	WS #2	Right	CRL Model E
7930	Cell G	WS #3	Left	CRL Model E
7930	Cell G	WS #3	Right	CRL Model E
7930	Cell G	WS #4	Left	CRL Model E
7930	Cell G	WS #4	Right	CRL Model E/F
7930	Cell C	Cubicle 5	Left	CRL Model E
7930	Cell C	Cubicle 5	Right	CRL Model E
7930	Cell C	WS #6	Left	CRL Model E
7930	Cell C	WS #6	Right	CRL Model E
7930	Cell C	FSW cubicle	Left	Modified CRL Model D
7930	Cell C	FSW cubicle	Right	Modified CRL Model D
7930	Cell C	FSW work table	Left	CRL Model A
7930	Cell C	FSW work table	Right	CRL Model A
7930	Cell B	WS #7	Left	CRL Model A
7930	Cell B	WS #7	Right	CRL Model A

BUILDING 4501

Building	Hot Cell	Location	Model
4501	A	Left	CRL Model E
4501	A	Right	CRL Model E
4501	B	Left	CRL Model E
4501	B	Right	CRL Model E
4501	C	Left	CRL Model E
4501	C	Right	CRL Model E
4501	D	Left	CRL Model E
4501	D	Right	CRL Model E

BUILDING 3047

Building	Hot Cell	Location	Model
3047	A	Left	CRL Model 8
3047	A	Right	CRL Model 8
3047	B	Left	CRL Model 8
3047	B	Right	CRL Model 8
3047	C	Left	CRL Model E
3047	C	Right	CRL Model E
3047	D	Left	CRL Model 8
3047	D	Right	CRL Model 8

BUILDING 3025E

Building	Hot Cell	Location	Model
3025E	Cell 1 West	Right	Model G
3025E	Cell 1 West	Left	Model G
3025E	Cell 1 East	Right	Model 8
3025E	Cell 1 East	Left	Model 8
3025E	Cell 2 West	Right	Model 8
3025E	Cell 2 West	Left	Model 8
3025E	Cell 2 East	Right	Model 8
3025E	Cell 2 East	Left	Model 8
3025E	Cell 3 West	Right	Model 8
3025E	Cell 3 West	Left	Model 8
3025E	Cell 3 East	Right	Model E
3025E	Cell 3 East	Left	Model 8
3025E	Cell 4	Right	Model 8
3025E	Cell 4	Left	Model 8
3025E	Cell 5	N/A	Model 4
3025E	Cell 6	West	Model 8
3025E	Cell 6	East Right	Model E
3025E	Cell 6	East Left	Model 8

BUILDING 3525

Building	Workstation	Location	Model
3525	WS-1	Right	CRL Model A
3525	WS-1	Left	CRL Model A
3525	WS-2	Right	CRL Model A
3525	WS-2	Left	CRL Model A
3525	WS-3	Right	CRL Model A
3525	WS-3	Left	CRL Model A
3525	WS-4	Right	CRL Model A
3525	WS-4	Left	CRL Model A
3525	WS-5 West	Right	CRL Model A
3525	WS-5 West	Left	CRL Model A
3525	WS-5 North	Right	CRL Model A
3525	WS-5 North	Left	CRL Model A
3525	WS-6	Right	CRL Model A
3525	WS-6	Left	CRL Model E
3525	WS-7	Right	WALISC Model A110
3525	WS-7	Left	WALISC Model A110
3525	WS-8	Right	WALISC Model A100
3525	WS-8	Left	WALISC Model A100
3525	WS-9 North	Right	CRL Model A
3525	WS-9 North	Left	CRL Model A
3525	WS-9 East	Right	CRL Model A
3525	WS-9 East	Left	CRL Model A
3525	WS-10	Right	CRL Model A
3525	WS-10	Left	CRL Model A
3525	WS-11	Right	CRL Model A
3525	WS-11	Left	CRL Model A
3525	WS-12	Right	CRL Model A
3525	WS-12	Left	CRL Model A
3525	WS-13	Right	CRL Model A
3525	WS-13	Left	CRL Model A
3525	CCCTF	Right	CRL Model G
3525	CCCTF	Left	CRL Model G
3525	WS-24	Right	CRL Model E/F
3525	WS-24	Left	CRL Model A
3525	WS-25	Right	CRL Model E
3525	WS-25	Left	CRL Model E
3525	WS-26	Right	CRL Model E
3525	WS-26	Left	CRL Model E/F
3525	WS-27	Right	CRL Model A
3525	WS-27	Left	CRL Model D
3525	SEM	Right	CRL Model 7

3525	SEM	Left	CRL Model 7
3525	IMGA	Right	CRL Model 7
3525	IMGA	Left	CRL Model 7
3525	North Cell		GM Model 300
3525	East Cell		GM Model 300
3525	West Cell		PAR