

**U.S. NUCLEAR REGULATORY COMMISSION  
NOTICE OF GRANT/ASSISTANCE AWARD**

<b>1. GRANT/AGREEMENT NO.</b> NRC-HQ-12-G-04-0084	<b>2. MODIFICATION NO.</b>	<b>3. PERIOD OF PERFORMANCE</b> FROM: 09/28/2012 TO: 09/27/2014	<b>4. AUTHORITY</b> Pursuant to Section 31b and 141b of the Atomic Energy Act of 1954, as amended												
<b>5. TYPE OF AWARD</b>  <input checked="" type="checkbox"/> GRANT <input type="checkbox"/> COOPERATIVE AGREEMENT	<b>6. ORGANIZATION TYPE</b>  State Public Institution of Higher Learning  DUNS: 847205572  NACIS: 611310	<b>7. RECIPIENT NAME, ADDRESS, and EMAIL ADDRESS</b>  Texas Engineering Experiment Station Texas A&M University Systems 1470 William D. Fitch Parkway College Station, TX 77845-4645 Email: <a href="mailto:awards@tamus.edu">awards@tamus.edu</a>													
<b>8. PROJECT TITLE:</b>  Testing of RCIC Performance for Mark I BWRs Under Prolonged Station Blackout Conditions															
<b>9. PROJECT WILL BE CONDUCTED PER GOVERNMENT'S/RECIPIENT'S PROPOSAL(S) DATED</b>  AND APPENDIX A-PROJECT GRANT PROVISIONS	<b>10. TECHNICAL REPORTS ARE REQUIRED</b>  <input type="checkbox"/> PROGRESS AND FINAL <input type="checkbox"/> FINAL ONLY <input checked="" type="checkbox"/> OTHER (Conference Proceedings)	<b>11. PRINCIPAL INVESTIGATOR(S) NAME, ADDRESS and EMAIL ADDRESS</b> Texas Engineering Experiment Station - Texas A&M University Systems Attn: Karen Vierow 1470 William D. Fitch Parkway College Station, TX 77845-4645 Email: <a href="mailto:Vierow@ne.tamu.edu">Vierow@ne.tamu.edu</a>													
<b>12. NRC PROGRAM OFFICE (NAME and ADDRESS)</b> NRC Attn: Heather Dempsey, <a href="mailto:Heather.Dempsey@nrc.gov">Heather.Dempsey@nrc.gov</a> Office of Regulatory Research MS: CS C6-D20, (301) 251-7666 11545 Rockville Pike Rockville, Maryland 20852 Andrew Nosek, Tech Analyst, <a href="mailto:Andrew.Nosek@nrc.gov">Andrew.Nosek@nrc.gov</a>	<b>13. ACCOUNTING and APPROPRIATION DATA</b> APPN. NO: 31X0200 B&R NO: 2012-60-11-6-110 JOB CODE: G6024 BOC NO: 4110 OFFICE ID NO: RES-12-335 FAMIS: GR0253	<b>14. METHOD OF PAYMENT</b>  <input type="checkbox"/> ADVANCE BY TREASURY CHECK <input type="checkbox"/> REIMBURSEMENT BY TREASURY CHECK <input type="checkbox"/> LETTER OF CREDIT <input checked="" type="checkbox"/> OTHER (SPECIFY) Electronic ASAP.gov (See Remarks in Item #20 "Payment Information")													
<b>15. NRC OBLIGATION FUNDS</b>  <table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:50%;">THIS ACTION</td> <td style="width:50%; text-align: right;">\$132,766.00</td> </tr> <tr> <td>PREVIOUS OBLIGATION</td> <td style="text-align: right;">_____</td> </tr> <tr> <td>TOTAL</td> <td style="text-align: right;">\$132,766.00</td> </tr> </table>		THIS ACTION	\$132,766.00	PREVIOUS OBLIGATION	_____	TOTAL	\$132,766.00	<b>16. TOTAL FUNDING AGREEMENT</b>  <table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:50%;">NRC</td> <td style="width:50%; text-align: right;">\$224,881.00</td> </tr> <tr> <td>RECIPIENT</td> <td style="text-align: right;">\$0.00</td> </tr> <tr> <td>TOTAL</td> <td style="text-align: right;">\$224,881.00</td> </tr> </table> <p style="font-size: small; margin-top: 5px;">This action provides funds for Fiscal Year FY2012 in the amount of \$132,766.00</p>		NRC	\$224,881.00	RECIPIENT	\$0.00	TOTAL	\$224,881.00
THIS ACTION	\$132,766.00														
PREVIOUS OBLIGATION	_____														
TOTAL	\$132,766.00														
NRC	\$224,881.00														
RECIPIENT	\$0.00														
TOTAL	\$224,881.00														
<b>17. NRC ISSUING OFFICE (NAME, ADDRESS and EMAIL ADDRESS)</b>  U.S. Nuclear Regulatory Commission Div. of Contracts M'Lita Carr, <a href="mailto:MLita.Carr@nrc.gov">MLita.Carr@nrc.gov</a> Mail Stop: TWB-01-B10M Rockville, MD 20852															
<b>18.</b>  Signature Not Required	<b>19. NRC CONTRACTING OFFICER</b>  <table style="width:100%; border-collapse: collapse;"> <tr> <td style="width:70%; text-align: center;"> <u>Erika Fam</u>            (Signature)         </td> <td style="width:30%; text-align: center;"> <u>09/28/2012</u>            (Date)         </td> </tr> <tr> <td colspan="2">NAME (TYPED) <u>Erika Fam</u></td> </tr> <tr> <td colspan="2">TITLE <u>Grants Officer</u></td> </tr> <tr> <td colspan="2">TELEPHONE NO. <u>(301) 492-3492</u></td> </tr> </table>			<u>Erika Fam</u> (Signature)	<u>09/28/2012</u> (Date)	NAME (TYPED) <u>Erika Fam</u>		TITLE <u>Grants Officer</u>		TELEPHONE NO. <u>(301) 492-3492</u>					
<u>Erika Fam</u> (Signature)	<u>09/28/2012</u> (Date)														
NAME (TYPED) <u>Erika Fam</u>															
TITLE <u>Grants Officer</u>															
TELEPHONE NO. <u>(301) 492-3492</u>															
<b>20. PAYMENT INFORMATION</b>  Payment will be made through the Automated Standard Application for Payment (ASAP.gov) unless the recipient has failed to comply with the program objectives, award conditions, Federal reporting requirements or other conditions specified in 2 CFR 215 (OMB Circular A110).															
<b>21. Attached is a copy of the "NRC General Provisions for Grants and Cooperative Agreements Awarded to Non-Government Recipients. Acceptance of these terms and conditions is acknowledged when Federal funds are used on this project.</b>															
<b>22. ORDER OF PRECEDENCE</b>  In the event of a conflict between the recipient's proposal and this award, the terms of the Award shall prevail.															
<b>23. By this award, the Recipient certifies that payment of any audit-related debt will not reduce the level of performance of any Federal Program.</b>															

**TEMPLATE - ADM001**

**SUNSI REVIEW COMPLETE**

**ADM002**

**ATTACHMENT A - SCHEDULE****A.1 PURPOSE OF GRANT**

The purpose of this Grant is to provide support to the "Testing of RCIC Performance for Mark I BWRs Under Prolonged Station Blackout Conditions" as described in Attachment B entitled "Program Description."

**A.2 PERIOD OF GRANT**

1. The effective date of this Grant is September 28, 2012. The estimated completion date of this Grant is September 27, 2014.

2. Funds obligated hereunder are available for program expenditures for the estimated period: September 28, 2012 – September 27, 2014.

**A. GENERAL**

1. Total Estimated NRC Amount:	\$244,881.00
2. Total Obligated Amount:	\$132,766.00
3. Cost-Sharing Amount:	\$0.00
4. Activity Title:	Testing of RCIC Performance for Mark I BWRs Under Prolonged Station Blackout Conditions
5. NRC Project Officer:	Heather Dempsey, Andrew Nosek (TA)
6. DUNS No.:	847205572

**B. SPECIFIC**

RFPA No.:	RES-12-335
FAMIS:	GR0253
Job Code:	G6024
BOC:	4110
B&R Number:	2012-60-11-6-174
Appropriation #:	31X0200
Amount Obligated:	\$132,766.00

**A.3 BUDGET**

Revisions to the budget shall be made in accordance with Revision of Grant Budget in accordance with 2 CFR 215.25.

	Year 1	Year 2
Personnel	\$12,606.00	\$12,984.00
Fringe	\$ 2,642.00	\$ 2,707.00
Travel	\$ 0.00	\$ 1,383.00
Equipment	\$ 7,000.00	\$ 0.00
Supplies	\$30,800.00	\$ 4,800.00
Other	\$41,611.00	\$42,906.00
Total Cost	\$94,659.00	\$64,780.00
Indirect Cost	\$38,107.00	\$27,335.00
Yearly Total	\$132,776.00	\$92,115.00

#### **A.4 AMOUNT OF AWARD AND PAYMENT PROCEDURES**

1. The total estimated amount of this Award is \$224,881.00 for the 2 year period.
2. NRC hereby obligates the amount of \$132,766.00 for program expenditures during the period set forth above and in support of the Budget above. The Grantee will be given written notice by the Contracting Officer when additional funds will be added. NRC is not obligated to reimburse the Grantee for the expenditure of amounts in excess of the total obligated amount.
3. Payment shall be made to the Grantee in accordance with procedures set forth in the Automated Standard Application For Payments (ASAP) Procedures set forth below.

#### **Attachment B – Program Description**

##### **PROGRAM DESCRIPTION**

#### **1. NRC Requirements Regarding Station Blackout**

The U.S. Nuclear Regulatory Commission (NRC) requires that Light Water Reactors (LWRs) be able to “withstand for a specified duration and recover from a station blackout”, as codified in 10 CFR 50.63 [NRC, 2007a] and discussed in Regulatory Guide 1.155 [NRC, 1988]. The core must be cooled and containment integrity maintained for the specified duration. Station blackout is defined in 10 CFR 50.2 [NRC, 2007b] as the loss of offsite power plus turbine trip and unavailability of onsite emergency ac power system. Available ac power to buses fed by station batteries is not assumed to be lost.

#### **2. Project Goals**

This proposed project will investigate the functionality of the Reactor Core Isolation Cooling system (RCIC) under elevated suppression pool temperature and hydrogen content, corresponding to prolonged station blackout conditions and will propose strategies for assuring RCIC operation during a prolonged station blackout. Knowledge of the extent of RCIC performance degradation, if any, will aid in ensuring technically sound strategies to cope with prolonged station blackout conditions. These strategies may include enhanced backup systems (e.g. more reserve battery power or other power supplies), RCIC modifications such as vent or exhaust locations, training on how to manually regulate the RCIC in the optimal manner (e.g. timing of actuation, rate of injection), or other.

#### **3. RCIC Description**

The number of US reactors with a Mark I containment currently stands at 23 [Mark I Containment Report, 2011]. The Mark 1 designs contain either an Isolation Condenser or an RCIC system to provide core cooling under reactor isolation conditions. The designs with an RCIC are under consideration in this proposal as the behavior of the RCIC and the torus wetwell design under extended station blackout conditions is of interest. The Mark I containment system is detailed in the 2011 report [Mark I Containment Report, 2011]. Briefly, this pressure suppression-type containment consists of an upside-down light-bulb shaped drywell around the reactor pressure vessel; a torus-shaped wetwell beneath the drywell; and drywell-to-wetwell vents. The water pool within the wetwell is termed the Suppression Pool because containment pressure is suppressed when steam vented from the drywell is condensed below the suppression pool water level. The drywell and wetwell are inerted to prevent burn by deflagration or detonation in the case that hydrogen is produced by core oxidation.

The later designs of Boiling Water Reactors (BWRs) with the Mark I containment employ a

RCIC to provide water to the reactor pressure vessel for decay heat removal under certain conditions. These conditions include isolation of the main steam lines and unavailability of the condensate and feedwater system. The RCIC is a key system in satisfying the station blackout requirement. The RCIC is classified as a safety-related system and is regularly tested to ensure reliability and functionality.

The RCIC consists of a steam turbine that powers the pump for providing water to the reactor pressure vessel [NRC, 2011a]. The turbine takes off of a main steam line and exhausts to the Suppression Pool. The RCIC is designed to deliver full load within 30 seconds of actuation and automatically regulate the reactor vessel water level between a prescribed upper level and a prescribed lower level.

The RCIC pump is designed to deliver the flow rate of water equal to the boil off rate of the reactor inventory 15 minutes after shutdown. Pump suction is from the Condensate Storage Tank until the level reaches a low level, after which the Suppression Pool serves as the alternate water source. The pump discharge is through a feedwater line to the reactor vessel. To ensure that the required Net Positive Suction Head is available, the pump is located at an elevation lower than both suction sources of water.

#### **4. RCIC Operation during the Fukushima Dai-ichi Station Blackouts**

The six reactors at the Fukushima Dai-ichi nuclear power plant are BWRs with a Mark I containment design, except for Unit 6 with a Mark II containment [IAEA, 2011]. Unit 1 is of the BWR/3 design and depends on an Isolation Condenser for decay heat removal while Units 2 and 3 are of the BWR/4 design and depend upon an RCIC.

During the March 11, 2011 events at the Fukushima Dai-ichi nuclear power plant, Units 1 through 3 had been in operation and lost adequate core cooling capability, Unit 4 lost adequate Spent Fuel Pool cooling during cold shutdown, and Units 5 and 6 were able to maintain sufficient cooling during cold shutdown. Units 2 and 3 are of primary interest for this proposal because the events resulted in operation of the Unit 2 and Unit 3 RCIC under extended station blackout conditions. Station blackout duration is typically on the order of 30 minutes, but the Fukushima Dai-ichi station blackouts persisted for over two weeks [Sehgal, 2011].

While all six units endured the earthquake ground accelerations, the subsequent tsunami inflicted insurmountable damage to several of the units. The tsunami height was up to 14 meters, about twice the design basis value. Under this assault, the ensuing flooding resulted in the loss of all twelve in-service emergency diesel generators (EDG) except for one at unit 6. At units 1 and 2, the DC batteries were flooded. The ultimate heat sink was lost because the sea water pumps and motors were destroyed.

Regarding RCIC operation, quoting from the IAEA Mission Report [2011]:

“...After the earthquake at Fukushima Dai-ichi, the RCIC systems in Units 2 and 3 were manually started and then tripped on a high RPV water level automatically before the tsunami. After the tsunami, the RCIC systems were started at 15:39 and 16:03 in Units 2 and 3, respectively. Conditions indicate that the RCIC system of Unit 2 operated as designed for about three days until 14 March at 13:25, although the actual status could not be confirmed in the control room. The RCIC system in Unit 3 stopped after about 19.5 hours, on 12 March at 11:36, and after an approximately 1 hour delay the turbine-driven high pressure coolant injection (HPCI) system started automatically on a low RPV water

level signal and remained operable for about 14 hours. Their failures will be investigated by TEPCO once stable conditions are achieved.

...After RCIC failed in Unit 2, approximately six hours elapsed until an alternative injection source could be established using a fire engine pump injecting sea water. ...

About 9197 tonnes of sea water was injected between 14 March and 26 March through the fire protection and MUWC lines connected to the low pressure coolant injection (LPCI) lines. ... After 26 March, a fresh water source was established...

...After the HPCI failed in Unit 3 on 13 March, approximately seven hours elapsed until an alternative injection source could be established. ... a total of 4495 tonnes of sea water was injected from 13 March until 25 March, at which time a fresh water source was established..."

The RCIC systems were most likely operating with higher suppression pool temperatures and hydrogen contents than they were designed for. Temperature increase may affect the RCIC pump operation when suction is from the suppression pool. Hydrogen content may impair the RCIC system performance when the noncondensable concentration is high in the wetwell and elevates the pressure and/or becomes flammable. These changes may also lead to two-phase flow into the RCIC pump.

#### **5. Factors Affecting RCIC Performance during Prolonged Station Blackout**

During station blackout, control power from station batteries is required, therefore one limitation the RCIC duration of operation is power availability.

Thermodynamic conditions also affect RCIC performance. The Suppression Pool temperature will increase during station blackout due to energy addition and water removal. Sources of energy addition to the Suppression Pool during RCIC operation include RCIC turbine exhaust and Safety Relief Valve (SRV) discharge. Water is removed from the suppression pool when pump suction is changed to the suppression pool, after the Condensate Storage Tank water has reached a low level. Other sources of flow paths to the Suppression Pool which may have minimal effect on the water temperature are for pump minimum flow protection and for discharge of noncondensable gases from the barometric condenser [Mark I Containment Report, 2011].

Hydrogen becomes a concern because a steam/hydrogen gas mixture flow into the wetwell would increase the suppression pool temperature and wetwell pressure. If the location of the turbine exhaust and pump suction are such that the RCIC pump could ingest hydrogen, pump performance and pump seal integrity could be jeopardized. In this proposed project, detonation and deflagration of hydrogen will not be considered.

It is evaluated herein that the focus of the RCIC deterioration studies should be placed on the RCIC pump. The pump is susceptible to reduced performance at elevated temperatures due to cavitation, two-phase flow at the pump suction and pump seal issues.

Turbine performance could be altered if the inlet gas contains a high concentration of hydrogen. A steam/hydrogen mixture would have a different enthalpy change from turbine inlet to outlet and possibly affect the turbine power output. Further investigation during the project will confirm whether the turbine effects are of lesser significance. If the turbine turns out to be a key issue,

an alternative to replacing it with a motor in the experimental tasks will be developed. Turbines themselves are generally of higher power output and expense than this project could accommodate.

Cavitation: As an impeller's blades move through the fluid being pumped, the fluid accelerates around the blades and low-pressure regions develop. If the total pressure were to decrease and approach the local vapor pressure, the fluid could vaporize and form bubbles. Cavitation is the formation of vapor bubbles within a liquid followed by sudden implosion of the bubbles. The pump suction is a location susceptible to cavitation because the suction lowers the local pressure to a value that the liquid can vaporize at the eye of the pump impeller. In normal operation, cavitation is designed out by ensuring that the pump has sufficient Net Positive Suction Head, that is, enough pressure at the suction to prevent liquid vaporization. During RCIC operation, the suppression pool temperature increases due to RCIC turbine exhaust and SRV discharge. The higher water temperature at the suction inlet raises the vapor pressure, resulting in thermodynamic conditions more conducive to vapor production and collapse. Since cavitation can induce locally strong shock waves, material can be removed from the impeller blades and result in premature pump failure. Cavitation can be detected audibly and by pump vibration.

Two-phase Flow at the Pump Suction: Once the core begins to oxidize, hydrogen will be present in the steam flowing out of the reactor and to the RCIC turbine. Discharge of hydrogen into the suppression pool through the turbine exhaust may result in a two-phase steam/hydrogen mixture entering the RCIC pump suction. Although the hydrogen bubbles will not implode, they can seriously degrade pump performance by generating local pressure disturbances, pump vibrations, etc.

One would expect that the location of the turbine exhaust location in relation to the RCIC pump would include a good separation distance. If not, depending upon the extent of suppression pool mixing and the amount of pump suction, hydrogen intake to the pump could occur. A description of the turbine exhaust and pump suction will be requested to confirm.

Pump Seal Issues: If hydrogen were to enter the pump seal chamber, the gas could migrate across the pump seal faces, causing them to run dry. This possibility will be investigated as part of the project since more information is needed on the pump seals. The solution is to use a dual seal system.

## **6. Calculations to Support the Need for RCIC Investigation**

Simplified mass and energy balances for a BWR/4 with Mark I containment and RCIC have been performed to estimate the time until core uncover during a station blackout [Levy, 2011]. The volumes of the wetwell and reactor pressure vessel were known as a function of elevation. The RCIC was assumed to provide back to the vessel an equal amount of water that was boiled off, until four hours, by which time the suppression pool temperature had risen by 90F. At this time, the RCIC was conservatively assumed to stop working. In the next 50 minutes, the core inventory boiled off due to decay heat and the water level dropped to the top of the core.

This calculation demonstrates the need for core inventory replenishment within a short time and without power, or alternatively, the need to extend the RCIC operating time.

## **7. Technical Approach**

The proposed work will be a two-year program with the following tasks:

Task 1 Estimation of reactor and containment conditions for a Mark I BWR/4 under hypothetical station blackout conditions

Task 2 Scaling analysis to design the RCIC test facility

Task 3 Facility design and construction

Task 4 Experimental testing of the RCIC capabilities under prolonged station blackout conditions to clarify effects of elevated water temperatures and increased presence of hydrogen

Task 5 Proposal of new strategies for prolonged RCIC operation

Task 6 Reactor safety analysis to simulate prolonged station blackout with new knowledge from testing and new strategies

Task 1 Estimation of reactor and containment conditions for a Mark I BWR/4 under hypothetical station blackout conditions.

The calculations by S. Levy will be used as a reference point and more detailed evaluations of the mass and energy redistributions in the reactor pressure vessel and containment during hypothetical station blackout conditions will be conducted. The water, steam and hydrogen inventory in the RCIC system and associated piping and their respective energy contents will be estimated. The GE BWR/4 Report describes a cycling of the RCIC to maintain the reactor vessel water level between Levels 2 and 8. Such operational procedures will also be included in the evaluation as information is available. For example, if the reactor vessel water level was to fall to Level 2 and the RCIC did not actuate, the time to core uncover would be minimized.

These calculations will be performed as scoping calculations by hand, followed by system analysis with the MELCOR severe accident code [Gauntt et al., 2005]. The scoping calculations will be sufficient to estimate the general conditions in the vessels and commence with the Task 2 scaling analysis.

MELCOR will be an appropriate calculation tool for more sophisticated analysis because the events under consideration will proceed to a beyond DBA scenario. Originally intended as a severe accident analysis code, MELCOR contains physics models needed for analysis of beyond DBA scenarios. Estimations of the time-dependent hydrogen generation rates, for example, will be essential to obtaining realistic conditions under which to test the RCIC performance and MELCOR includes hydrogen generation models. These calculations will support the experimental program described as Task 3 and prepare for reactor safety analysis, proposed as Task 6.

While the MELCOR calculations are necessary to arrive at appropriate conditions for RCIC testing, they do not obviate the need for experimental testing. Reactor safety codes will not be able to replicate the behavior of the most susceptible component in the RCIC system, namely, the RCIC pump. The codes generally have simplified turbomachinery models built in that would not capture performance-defining phenomena such as cavitation, loss of Net Positive Suction Head or pump behavior if two-phase flow comes to be at the pump suction.

It is anticipated that the NRC could provide information on a representative BWR/4 and Mark I containment regarding geometry, operating procedures and thermodynamic conditions. The proposed work would be accelerated if an existing MELCOR input deck could be provided.

Task 2 Scaling analysis to design the RCIC test facility

A careful scaling analysis will be performed to design an RCIC test facility capable of producing the phenomena that would occur in a reactor under postulated station blackout conditions. The containment temperatures and pressures will likely be fully reproducible, if this turns out to be

desirable. Key elevations will be maintained, because they affect factors such as Net Positive Suction Head. A simulant gas such as helium will be used in place of hydrogen. Helium is not volatile and has a similar molecular weight to that of hydrogen. As mentioned earlier, deflagration and detonation of hydrogen will not be considered in this proposal.

The greatest scaling deficiency will be in the pressure of the reactor pressure vessel. The PI maintains a 150-kW steam generator that is capable of operation at 120 psia (about 0.8 MPa). The RCIC turbine is designed to operate with a steam supply pressure between 150 and 1135 psig [NRC, 2011a]. A technically-defendable means for accommodating the pressure scaling will be sought that allows for proper steam release from the steam generator and water discharge from the RCIC pump.

### Task 3 Facility design and construction

The PI has a 150-kW steam generator that can be used as the reactor pressure vessel and steam supply. The other major facility components will be comprised of a hot water pump powered by a motor, a pressure vessel representing the Mark I wetwell with suppression pool, various valves and valve controllers and connecting piping. The entire facility will be constructed out of stainless steel (SS304) to withstand high temperatures, pressures and the steam environment. Two-inch thick fiberglass insulation will be applied to the entire facility to prevent steam condensation and cooling of the hot water. Deionized water will be used for both the steam and the suppression pool water.

Since the RCIC turbine is not expected to be the major cause of RCIC performance deterioration, a motor will be used instead of a turbine to drive the test facility's RCIC pump. Turbines are typically of much greater horsepower than could be accommodated in this project and would also be cost-prohibitive.

The steam generator consists of a pressure vessel, immersion heaters, and a control panel. The pressure vessel was designed by the contractor and manufactured by Kennedy Tank and Manufacturing Co., Inc. of Indianapolis, IN. The steam generator is shown uninsulated in Figure 2. The pressure vessel shell is Schedule 10 stainless steel 304 pipe, 60 inches in height and 24 inches in diameter, along with two 24-inch, Schedule 10 stainless steel end caps that were welded to the top and bottom of the body. A drain line from the bottom center, two blowdown lines from the top, weld necks for the heaters and several other penetrations were added. Figure 2 Steam generator before insulating The two pressure relief valves are ½-inch bronze valves manufactured by Kunkle. A vacuum breaker line with a check valve inboard of the vacuum breaker is also attached. During cool down, the pressure falls below atmospheric pressure, causing the vacuum breaker valve to open. This allows air to flow into the steam supply and avoids placing the vessel under a vacuum.

Three 8-inch, flanged immersion heaters manufactured by Watlow Process Systems were purchased for the current project. The heaters have inconel sheaths. Each heater has a total output of 50 kW. Two of the heaters have two 25 kW circuits and one heater has eight 6.25 kW circuits. Two 2 kW heaters and one 3 kW heater are also installed on the pressure vessel. The possible power levels are up to 150 kW in increments of 2.0 kW. Type K thermocouples are used to measure the heater sheath temperature. Watlow Series 146 Temperature Regulators receive the thermocouple signal and break the circuit if an overtemperature condition is detected. The temperature regulators are set to activate when the sheath temperature exceeds 600 °F.

Power is supplied to the steam generator from a 200 amp, 180 kW source via the control panel.



The control panel was custom designed and manufactured by Watlow. Via the control panel, up to 50 kW may be supplied to each of the heaters. Systems engineering support for the steam generator, heaters, and control panel is supplied by Thermtech Systems, Inc.

Orion instruments supplied the magnetic liquid level indicator. This device shows the water level inside the steam generator without exposing glass to high pressure, as is the usual design of sight glasses. The Atlas model indicator comes with a Reed switch device which the PI hooked up to shut off all heater power when the liquid level falls below a prescribed level.

Relief valves from the steam generator to the suppression pool will be sized and have opening and closing set points such that the discharge will be representative of SRV cycling. Manual opening and closing of the valves will be left as a possibility in the design.

A line from the steam generator to the suppression pool will transport steam that represents the turbine exhaust. The flow rate as a function of time will be determined from analysis of actual plant specifications, not currently in hand.

The optimal method for injecting gas that simulates the hydrogen will be determined. The desirable simulant gas will have a low molecular weight, similar to hydrogen. Two options for gas injection exist. The gas may be injected into the steam generator and assumed to mix well with steam prior to leaving the steam generator. Alternatively, the gas may be injected into the line transporting steam out of the steam generator, for a direct simulant gas flow measurement.

If it is determined that an additional line to the suppression pool is needed for simulating flow from the RCIC pump minimum flow protection line or for noncondensable gases from the barometric condenser, this line will be included with a flow control valve.

The pump will be selected to have as many similarities as possible to those used in the RCIC. The RCIC pump is described as a turbine-driven, horizontal multi-stage centrifugal pump [NRC, 2011a]. The objective of having a multi-stage pump is generally to obtain higher head (pressure difference from suction to discharge). The multi-stage effect may be simulated in this facility by having two pumps in series. More information is needed such as the pump performance curve (discharge pressure vs. volumetric flow rate), temperature rating and the pump operating procedures.

Location of the pump is also important to assure that the required Net Positive Suction Head is available. The pump will be located below the suppression pool suction point at an elevation to satisfy this requirement.

The return line from the RCIC pump to the steam generator will include valve control to allow for appropriate water addition rate.

Temperature, absolute pressure, differential pressure, and flow rates will be recorded. The data will be received by a data acquisition system assembled from National Instruments components already existing in the PI's lab. The National Instruments LabVIEW software will be used to display and save data.

Instrumentation on the steam generator already exists. For the rest of the system, new equipment will be purchased. The thermocouples will be T-type (copper-constantan). Pressure transducers, either from Honeywell or Omega, will be acquired to measure vessel pressures. Water level in the wetwell will be recorded, perhaps with a pressure transducer, although S.

Levy has pointed out that water level measurement was inaccurate in the Fukushima reactors when the liquid was not single phase [Levy, 2011]. Flow rates from the steam generator to the wet well and from the RCIC pump back to the steam generator will be recorded, along with the simulant gas flow rate.

Task 4 Experimental testing of the RCIC capabilities under prolonged station blackout conditions to clarify effects of elevated water temperatures and increased presence of hydrogen

The steam generator will start from a steady pressure and temperature level. From there, heater power can be decreased in a manner to replicate the power decrease of decay heat with time. As mentioned earlier, the power level can be adjusted between 0 and 150 kW in 2-kW increments.

A system energy balance will be performed to determine the operating procedures. The energy that would have been deposited in the RCIC turbine to power the motor will be discharged outside of the experimental facility. The steam energy equivalent of the turbine exhaust will be vented below the suppression pool water level. The RCIC pump acquired for this project will have suction in the suppression pool and discharge to a line simulating the feedwater line in a BWR/4.

The projected ranges of test conditions are listed in Table 1 and will be confirmed as part of the facility design. These ranges will allow for saturated water in the suppression pool, which could severely impact pump performance.

Table 1 Tentative range of test conditions

Parameter Range

Steam Generator Pressure (psig) 15-120 psia

Wetwell Air Space Pressure (atm) 15-60 psia

Steam Flow Rate out of Steam Generator (kW) 0 – 140 kW

Steam Temp. out of Steam Generator (°C) 100-170°C

Suppression Pool Water Temperature (°C) 100-170°C

Simulant Gas Volumetric Concentration (%) TBD<sub>1</sub>

<sub>1</sub>To be evaluated by MELCOR calculations of oxidation rate.

Tests will be conducted to cover the expected ranges of conditions during a prolonged station blackout.

Key test results will include the ability of the pump to operate at higher suppression pool temperatures (lower or no water subcooling) and greater simulant gas content (higher pump suction quality) and longer periods of time. Reduced subcooling and higher quality at the pump suction are threats to pump performance because two-phase flow may enter the pump and/or pump cavitation may occur. Higher temperatures are a threat to the integrity of the pump seals. Higher pressure in the wetwell due to noncondensable gases may enhance pump performance because it will aid in satisfying the Net Positive Suction Head requirement.

Task 5 Proposal of new strategies for prolonged RCIC operation

Several new strategies can be envisioned to enable prolonged operation of the RCIC system. Depending on the results of the experimental investigation, strategies will be selected and further developed. They will be evaluated analytically in Task 6. The steps will be experimentally verified if time and funding allow.

If the system performs well under all conditions, steps to prolong RCIC operation could include:

- Added reserve battery power for the RCIC
- Revised operating procedures to optimize RCIC operation in terms of time of actuation and duration of use

If RCIC performance is affected significantly by elevated water temperature at the pump suction, steps to prolong RCIC operation could include:

- Rethinking of turbine exhaust procedures to the suppression pool
- Use of a containment cooling system to withdraw SP water and replace it with cooler water, noting that ac power will not be available
- Cooling of suppression pool water in place, noting that ac power will not be available
- Development of SRV venting procedures to reduce heat load to the suppression pool while still regulating reactor pressure vessel pressure

If performance is negatively affected by the simulant gas, steps to prolong RCIC operation could include:

- Pump seal modification
- Routing of the pump suction piping such that noncondensable gas is not ingested
- Reconsideration of wetwell venting procedures.

#### Task 6 Reactor safety analysis to simulate prolonged station blackout with new knowledge from testing and new strategies

The analyses conducted in Task 3 will be resumed in Task 6 to utilize the knowledge obtained from the experimental program and implement the strategies proposed in Task 5. First, the RCIC performance characteristics observed in the experiments will be reflected in full-scale simulations with the MELCOR code. These characteristics will include duration of operation, pumping capability as suppression pool temperature and gas content increases, suppression pool water level change, etc.

These calculations will be at full reactor scale. The results of these calculations will be the validation of the proposed strategies for prolonged RCIC operation. The final outcomes will be increased knowledge of the RCIC operation characteristics and proposals of strategies for handling prolonged station blackouts.

#### **8. Deliverables**

The deliverables will consist of the following:

- Experimental data for RCIC operation under elevated suppression pool water temperature and gas content
- Evaluation of the effects of elevated temperatures and gas content on RCIC operation for prolonged periods of time
- MELCOR analyses of the RCIC operation at reactor scale
- Proposals of strategies to promote RCIC operation during prolonged station blackout
- Progress reports as desired by the sponsor
- Technical report documenting the entire effort

## Attachment C – Standard Terms and Conditions

### The Nuclear Regulatory Commission's Standard Terms and Conditions for U.S. Nongovernmental Grantees

#### Preface

This award is based on the application submitted to, and as approved by, the Nuclear Regulatory Commission (NRC) under the authorization 42 USC 2051(b) pursuant to section 31b and 141b of the Atomic Energy Act of 1954, as amended, and is subject to the terms and conditions incorporated either directly or by reference in the following:

- Grant program legislation and program regulation cited in this Notice of Grant Award.
- Restrictions on the expenditure of Federal funds in appropriation acts, to the extent those restrictions are pertinent to the award.
- Code of Federal Regulations/Regulatory Requirements - 2 CFR 215 Uniform Administrative Requirements For Grants And Agreements With Institutions Of Higher Education, Hospitals, And Other Non-Profit Organizations (OMB Circulars), as applicable.

To assist with finding additional guidance for selected items of cost as required in 2 CFR 220, 2 CFR 225, and 2 CFR 230 this URL to the Office of Management and Budget Cost Circulars is included for reference to:

A-21 (now 2 CFR 220)  
A-87 (now 2 CFR 225)  
A-122 (now 2 CFR 230)  
A-102:

[http://www.whitehouse.gov/omb/circulars\\_index-ffm](http://www.whitehouse.gov/omb/circulars_index-ffm)

Any inconsistency or conflict in terms and conditions specified in the award will be resolved according to the following order of precedence: public laws, regulations, applicable notices published in the Federal Register, Executive Orders (EOs), Office of Management and Budget (OMB) Circulars, the Nuclear Regulatory Commission's (NRC) Mandatory Standard Provisions, special award conditions, and standard award conditions.

Certifications and Representations: These terms incorporate the certifications and representations required by statute, executive order, or regulation that were submitted with the SF424B application through [Grants.gov](http://Grants.gov).

#### **I. Mandatory General Requirements**

The order of these requirements does not make one requirement more important than any other requirement.

##### **1. Applicability of 2 CFR Part 215**

a. All provisions of 2 CFR Part 215 and all Standard Provisions attached to this grant/cooperative agreement are applicable to the Grantee and to sub-recipients which meet the definition of "Grantee" in Part 215, unless a section specifically excludes a sub-recipient from coverage. The

Grantee and any sub-recipients must, in addition to the assurances made as part of the application, comply and require each of its sub-awardees employed in the completion of the project to comply with Subpart C of 2 CFR 215 and include this term in lower-tier (subaward) covered transactions.

b. Grantees must comply with monitoring procedures and audit requirements in accordance with OMB Circular A-133. < [http://www.whitehouse.gov/omb/circulars/a133\\_compliance/08/08toc.aspx](http://www.whitehouse.gov/omb/circulars/a133_compliance/08/08toc.aspx) >

## **2. Award Package**

### **§ 215.41 Grantee responsibilities.**

The Grantee is obligated to conduct such project oversight as may be appropriate, to manage the funds with prudence, and to comply with the provisions outlined in 2 CFR 215.41. Within this framework, the Principal Investigator (PI) named on the award face page, Block 11, is responsible for the scientific or technical direction of the project and for preparation of the project performance reports. This award is funded on a cost reimbursement basis not to exceed the amount awarded as indicated on the face page, Block 16., and is subject to a refund of unexpended funds to NRC.

The standards contained in this section do not relieve the Grantee of the contractual responsibilities arising under its contract(s). The Grantee is the responsible authority, without recourse to the NRC, regarding the settlement and satisfaction of all contractual and administrative issues arising out of procurements entered into in support of an award or other agreement. This includes disputes, claims, protests of award, source evaluation or other matters of a contractual nature. Matters concerning violation of statute are to be referred to such Federal, State or local authority as may have proper jurisdiction.

### **Subgrants**

#### **Appendix A to Part 215—Contract Provisions**

Sub-recipients, sub-awardees, and contractors have no relationship with NRC under the terms of this grant/cooperative agreement. All required NRC approvals must be directed through the Grantee to NRC. See 2 CFR 215 and 215.41.

### **Nondiscrimination**

(This provision is applicable when work under the grant/cooperative agreement is performed in the U.S. or when employees are recruited in the U.S.)

No U.S. citizen or legal resident shall be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity funded by this award on the basis of race, color, national origin, age, religion, handicap, or sex. The Grantee agrees to comply with the non-discrimination requirements below:

Title VI of the Civil Rights Act of 1964 (42 USC §§ 2000d et seq)

Title IX of the Education Amendments of 1972 (20 USC §§ 1681 et seq)

Section 504 of the Rehabilitation Act of 1973, as amended (29 USC § 794)

The Age Discrimination Act of 1975, as amended (42 USC §§ 6101 et seq)

The Americans with Disabilities Act of 1990 (42 USC §§ 12101 et seq)

Parts II and III of EO 11246 as amended by EO 11375 and 12086.

EO 13166, "Improving Access to Services for Persons with Limited English Proficiency."

Any other applicable non-discrimination law(s).

Generally, Title VI of the Civil Rights Act of 1964, 42 USC § 2000e et seq, provides that it shall be an unlawful employment practice for an employer to discharge any individual or otherwise to discriminate against an individual with respect to compensation, terms, conditions, or privileges of employment because of such individual's race, color, religion, sex, or national origin. However, Title VI, 42 USC § 2000e-1(a), expressly exempts from the prohibition against discrimination on the basis of religion, a religious corporation, association, educational institution, or society with respect to the employment of individuals of a particular religion to perform work connected with the carrying on by such corporation, association, educational institution, or society of its activities.

#### **Modifications/Prior Approval**

NRC's prior written approval may be required before a Grantee makes certain budget modifications or undertakes particular activities. If NRC approval is required for changes in the grant or cooperative agreement, it must be requested of, and obtained from, the NRC Grants Officer in advance of the change or obligation of funds. All requests for NRC prior approval should be made, in writing (which includes submission by e-mail), to the designated Grants Specialist and Program Office no later than 30 days before the proposed change. The request must be signed by both the PI and the authorized organizational official. Failure to obtain prior approval, when required, from the NRC Grants Officer may result in the disallowance of costs, or other enforcement action within NRC's authority.

#### **Lobbying Restrictions**

The Grantee will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

The Grantee shall comply with provisions of 31 USC § 1352. This provision generally prohibits the use of Federal funds for lobbying in the Executive or Legislative Branches of the Federal Government in connection with the award, and requires disclosure of the use of non-Federal funds for lobbying.

The Grantee receiving in excess of \$100,000 in Federal funding shall submit a completed Standard Form (SF) LLL, "Disclosure of Lobbying Activities," regarding the use of non-Federal funds for lobbying within 30 days following the end of the calendar quarter in which there occurs any event that requires disclosure or that materially affects the accuracy of the information contained in any disclosure form previously filed. The Grantee must submit the SF-LLL, including those received from sub-recipients, contractors, and subcontractors, to the Grants Officer.

#### **§ 215.13 Debarment And Suspension.**

The Grantee agrees to notify the Grants Officer immediately upon learning that it or any of its principals:

- (1) Are presently excluded or disqualified from covered transactions by any Federal department or agency;
- (2) Have been convicted within the preceding three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of

records, making false statements, tax evasion, receiving stolen property, making false claims, or obstruction of justice; commission of any other offense indicating a lack of business integrity or business honesty that seriously and directly affects your present responsibility;

(3) Are presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph (1)(b); and

(4) Have had one or more public transactions (Federal, State, or local) terminated for cause or default within the preceding three years.

b. The Grantee agrees that, unless authorized by the Grants Officer, it will not knowingly enter into any subgrant or contracts under this grant/cooperative agreement with a person or entity that is included on the Excluded Parties List System (<http://epls.arnet.gov>).

The Grantee further agrees to include the following provision in any subgrant or contracts entered into under this award:

'Debarment, Suspension, Ineligibility, and Voluntary Exclusion

The Grantee certifies that neither it nor its principals is presently excluded or disqualified from participation in this transaction by any Federal department or agency. The policies and procedures applicable to debarment, suspension, and ineligibility under NRC-financed transactions are set forth in 2 CFR Part 180.'

#### **Drug-Free Workplace**

The Grantee must be in compliance with The Federal Drug Free Workplace Act of 1988. The policies and procedures applicable to violations of these requirements are set forth in 41 USC 702.

#### **Implementation of E.O. 13224 -- Executive Order On Terrorist Financing**

The Grantee is reminded that U.S. Executive Orders and U.S. law prohibits transactions with, and the provision of resources and support to, individuals and organizations associated with terrorism. It is the legal responsibility of the Grantee to ensure compliance with these Executive Orders and laws. This provision must be included in all contracts/sub-awards issued under this grant/cooperative agreement.

Award Grantees must comply with Executive Order 13224, Blocking Property and Prohibiting Transactions with Persons who Commit, Threaten to Commit, or Support Terrorism. Information about this Executive Order can be found at: [www.fas.org/irp/offdocs/eo/eo-13224.htm](http://www.fas.org/irp/offdocs/eo/eo-13224.htm).

#### **Procurement Standards. § 215.40-48**

Sections 215.41 through 215.48 set forth standards for use by Grantees in establishing procedures for the procurement of supplies and other expendable property, equipment, real property and other services with Federal funds. These standards are furnished to ensure that such materials and services are obtained in an effective manner and in compliance with the provisions of applicable Federal statutes and executive orders. No additional procurement standards or requirements shall be imposed by the Federal awarding agencies upon Grantees, unless specifically required by Federal statute or executive order or approved by OMB.

#### **Travel**

Travel must be in accordance with the Grantee's Travel Regulations or the US Government Travel Policy and Regulations at: [www.gsa.gov/federaltravelregulation](http://www.gsa.gov/federaltravelregulation) and the per diem rates set forth at: [www.gsa.gov/perdiem](http://www.gsa.gov/perdiem), absent Grantee's travel regulation. Travel costs for the grant must be consistent with provisions as established in Appendix A to 2 CFR 220 (J.53). All other travel, domestic or international, must not increase the total estimated award amount.

**Domestic Travel:**

Domestic travel is an appropriate charge to this award and prior authorization for specific trips are not required, if the trip is identified in the Grantee's approved program description and approved budget. Domestic trips not stated in the approved budget require the written prior approval of the Grants Officer, and must not increase the total estimated award amount.

All common carrier travel reimbursable hereunder shall be via the least expensive class rates consistent with achieving the objective of the travel and in accordance with the Grantee's policies and practices. Travel by first-class travel is not authorized unless prior approval is obtained from the Grants Officer.

**International Travel:**

**International travel requires PRIOR written approval by the Project Officer and the Grants Officer, even if the international travel is stated in the approved program description and the approved budget.**

The Grantee shall comply with the provisions of the Fly American Act (49 USC 40118) as implemented through 41 CFR 301-10.131 through 301-10.143.

**Property and Equipment Management Standards**

Property and equipment standards of this award shall follow provisions as established in 2 CFR 215.30-37.

**Procurement Standards**

Procurement standards of this award shall follow provisions as established in 2 CFR 215.40-48

**Intangible and Intellectual Property**

Intangible and intellectual property of this award shall generally follow provisions established in 2 CFR 215.36.

**Inventions Report** - The Bayh-Dole Act (P.L. 96-517) affords Grantees the right to elect and retain title to inventions they develop with funding under an NRC grant award ("subject inventions"). In accepting an award, the Grantee agrees to comply with applicable NRC policies, the Bayh-Dole Act, and its Government-wide implementing regulations found at Title 37, Code of Federal Regulations (CFR) Part 401. A significant part of the regulations require that the Grantee report all subject inventions to the awarding agency (NRC) as well as include an acknowledgement of federal support in any patents. NRC participates in the trans-government Interagency Edison system (<http://www.iedison.gov>) and expects NRC funding Grantees to use this system to comply with Bayh-Dole and related intellectual property reporting requirements. The system allows for Grantees to submit reports electronically via the Internet. In addition, the invention must be reported in continuation applications (competing or non-competing).

**Patent Notification Procedures**- Pursuant to EO 12889, NRC is required to notify the owner of any valid patent covering technology whenever the NRC or its financial assistance Grantees, without making a patent search, knows (or has demonstrable reasonable grounds to know) that



technology covered by a valid United States patent has been or will be used without a license from the owner. To ensure proper notification, if the Grantee uses or has used patented technology under this award without license or permission from the owner, the Grantee must notify the Grants Officer. This notice does not necessarily mean that the Government authorizes and consents to any copyright or patent infringement occurring under the financial assistance.

**Data, Databases, and Software** - The rights to any work produced or purchased under a NRC federal financial assistance award are determined by 2 CFR 215.36. Such works may include data, databases or software. The Grantee owns any work produced or purchased under a NRC federal financial assistance award subject to NRC's right to obtain, reproduce, publish or otherwise use the work or authorize others to receive, reproduce, publish or otherwise use the data for Government purposes.

**Copyright** - The Grantee may copyright any work produced under a NRC federal financial assistance award subject to NRC's royalty-free nonexclusive and irrevocable right to reproduce, publish or otherwise use the work or authorize others to do so for Government purposes. Works jointly authored by NRC and Grantee employees may be copyrighted but only the part authored by the Grantee is protected because, under 17 USC § 105, works produced by Government employees are not copyrightable in the United States. On occasion, NRC may ask the Grantee to transfer to NRC its copyright in a particular work when NRC is undertaking the primary dissemination of the work. Ownership of copyright by the Government through assignment is permitted under 17 USC § 105.

**Records Retention and Access Requirements** for records of the Grantee shall follow established provisions in 2 CFR 215.53.

**Organizational Prior Approval System**

In order to carry out its responsibilities for monitoring project performance and for adhering to award terms and conditions, each Grantee organization shall have a system to ensure that appropriate authorized officials provide necessary organizational reviews and approvals in advance of any action that would result in either the performance or modification of an NRC supported activity where prior approvals are required, including the obligation or expenditure of funds where the governing cost principles either prescribe conditions or require approvals.

The Grantee shall designate an appropriate official or officials to review and approve the actions requiring NRC prior approval. Preferably, the authorized official(s) should be the same official(s) who sign(s) or countersign(s) those types of requests that require prior approval by NRC. The authorized organization official(s) shall not be the principal investigator or any official having direct responsibility for the actual conduct of the project, or a subordinate of such individual.

**Conflict Of Interest Standards** for this award shall follow OCOI requirements set forth in Section 170A of the Atomic Energy Act of 1954, as amended, and provisions set forth at 2 CFR 215.42 Codes of Conduct.

**Dispute Review Procedures**

a. Any request for review of a notice of termination or other adverse decision should be addressed to the Grants Officer. It must be postmarked or transmitted electronically no later than 30 days after the postmarked date of such termination or adverse decision from the Grants Officer.

- b. The request for review must contain a full statement of the Grantee's position and the pertinent facts and reasons in support of such position.
- c. The Grants Officer will promptly acknowledge receipt of the request for review and shall forward it to the Director, Office of Administration, who shall appoint an intra-agency Appeal Board to review a grantee appeal of an agency action, if required, which will consist of the program office director, the Deputy Director of Office of Administration, and the Office of General Counsel.
- d. Pending resolution of the request for review, the NRC may withhold or defer payments under the award during the review proceedings.
- e. The review committee will request the Grants Officer who issued the notice of termination or adverse action to provide copies of all relevant background materials and documents. The committee may, at its discretion, invite representatives of the Grantee and the NRC program office to discuss pertinent issues and to submit such additional information as it deems appropriate. The chairman of the review committee will insure that all review activities or proceedings are adequately documented.
- f. Based on its review, the committee will prepare its recommendation to the Director, Office of Administration, who will advise the parties concerned of his/her decision.

**Termination and Enforcement.** Termination of this award by default or by mutual consent shall follow provisions as established in 2 CFR 215.60-62.

**Monitoring and Reporting § 215.50-53**

- a. Grantee Financial Management systems must comply with the established provisions in 2 CFR 215.21
- Payment – 2 CFR 215.22
  - Cost Share – 2 CFR 215.23
  - Program Income – 2 CFR 215.24
    - Earned program income, if any, shall be added to funds committed to the project by the NRC and Grantee and used to further eligible project or program objectives or deducted from the total project cost allowable cost as directed by the Grants Officer or the terms and conditions of award.
  - Budget Revision – 2 CFR 215.25
    - The Grantee is required to report deviations from the approved budget and program descriptions in accordance with 2 CFR 215.25, and request prior written approval from the Program Officer and the Grants Officer.
    - The Grantee is not authorized to rebudget between direct costs and indirect costs without written approval of the Grants Officer.
    - The Grantee is authorized to transfer funds among direct cost categories up to a cumulative 10 percent of the total approved budget. The Grantee is not allowed to transfer funds if the transfer would cause any Federal appropriation to be used for purposes other than those consistent with the original intent of the appropriation.
    - Allowable Costs – 2 CFR 215.27

**b. Federal Financial Reports**

The Grantee shall submit a "Federal Financial Report" (SF-425) on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period. A final SF-425 is due within 90 days after expiration of the award. The report should be submitted electronically to: Grants\_FFR.Resource@NRC.GOV and RESGrants.Resource@nrc.gov. (**NOTE: There is an underscore between Grants and FFR**).

**Period of Availability of Funds 2 CFR § 215.28**

- a. Where a funding period is specified, a Grantee may charge to the grant only allowable costs resulting from obligations incurred during the funding period and any pre-award costs authorized by the NRC.
- b. Unless otherwise authorized in 2 CFR 215.25(e)(2) or a special award condition, any extension of the award period can only be authorized by the Grants Officer in writing. Verbal or written assurances of funding from other than the Grants Officer shall not constitute authority to obligate funds for programmatic activities beyond the expiration date.
- c. The NRC has no obligation to provide any additional prospective or incremental funding. Any modification of the award to increase funding and to extend the period of performance is at the sole discretion of the NRC.
- d. Requests for extensions to the period of performance should be sent to the Grants Officer at least 30 days prior to the grant/cooperative agreement expiration date. Any request for extension after the expiration date may not be honored.

**Automated Standard Application For Payments (ASAP) Procedures**

Unless otherwise provided for in the award document, payments under this award will be made using the Department of Treasury's Automated Standard Application for Payment (ASAP) system < <http://www.fms.treas.gov/asap/> >. Under the ASAP system, payments are made through preauthorized electronic funds transfers, in accordance with the requirements of the Debt Collection Improvement Act of 1996. In order to receive payments under ASAP, Grantees are required to enroll with the Department of Treasury, Financial Management Service, and Regional Financial Centers, which allows them to use the on-line method of withdrawing funds from their ASAP established accounts. The following information will be required to make withdrawals under ASAP: (1) ASAP account number – the award number found on the cover sheet of the award; (2) Agency Location Code (ALC) – 31000001; and Region Code. Grantees enrolled in the ASAP system do not need to submit a "Request for Advance or Reimbursement" (SF-270), for payments relating to their award.

**Audit Requirements**

Organization-wide or program-specific audits shall be performed in accordance with the Single Audit Act Amendments of 1996, as implemented by OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

<http://www.whitehouse.gov/omb/circulars/a133/a133.html> Grantees are subject to the provisions of OMB Circular A-133 if they expend \$500,000 or more in a year in Federal awards.

The Form SF-SAC and the Single Audit Reporting packages for fiscal periods ending on or after January 1, 2008 must be submitted online.

1. Create your online report ID at <http://harvester.census.gov/fac/collect/ddeindex.html>
2. Complete the Form SF-SAC
3. Upload the Single Audit
4. Certify the Submission
5. Click "Submit."

Organizations expending less than \$500,000 a year are not required to have an annual audit for that year but must make their grant-related records available to NRC or other designated officials for review or audit.

### **III. Programmatic Requirements**

#### **Performance (Technical) Reports**

a. The Grantee shall submit performance (technical) reports electronically on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period unless otherwise authorized by the Grants Officer. Performance reports should be sent to the Program Officer and Technical Analyst at the email address indicated in Block 12 of the Notice of Award, and to the Grants Officer at: [Grants\\_PPR.Resource@nrc.gov](mailto:Grants_PPR.Resource@nrc.gov) and [RESGrants.Resource@nrc.gov](mailto:RESGrants.Resource@nrc.gov). (***NOTE: There is an underscore between Grants and PPR.***)

b. Unless otherwise specified in the award provisions, performance (technical) reports shall contain brief information as prescribed in the applicable uniform administrative requirements 2 CFR [§215.51](#) which are incorporated in the award.

c. The Office of Regulatory Research requires the submission of progress reports on the SF-RPPR on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period.

#### **Unsatisfactory Performance**

Failure to perform the work in accordance with the terms of the award and maintain at least a satisfactory performance rating or equivalent evaluation may result in designation of the Grantee as high risk and assignment of special award conditions or other further action as specified in the standard term and condition entitled "Termination."

Failure to comply with any or all of the provisions of the award may have a negative impact on future funding by NRC and may be considered grounds for any or all of the following actions: establishment of an accounts receivable, withholding of payments under any NRC award, changing the method of payment from advance to reimbursement only, or the imposition of other special award conditions, suspension of any NRC active awards, and termination of any NRC award.

#### **Other Federal Awards With Similar Programmatic Activities**

The Grantee shall immediately provide written notification to the NRC Project Officer and the Grants Officer in the event that, subsequent to receipt of the NRC award, other financial assistance is received to support or fund any portion of the program description incorporated into the NRC award. NRC will not pay for costs that are funded by other sources.

**Prohibition Against Assignment By The Grantee**

The Grantee shall not transfer, pledge, mortgage, or otherwise assign the award, or any interest therein, or any claim arising thereunder, to any party or parties, banks, trust companies, or other financing or financial institutions without the express written approval of the Grants Officer.

**Site Visits**

The NRC, through authorized representatives, has the right, at all reasonable times, to make site visits to review project accomplishments and management control systems and to provide such technical assistance as may be required. If any site visit is made by the NRC on the premises of the Grantee or contractor under an award, the Grantee shall provide and shall require his/her contractors to provide all reasonable facilities and assistance for the safety and convenience of the Government representative in the performance of their duties. All site visits and evaluations shall be performed in such a manner as will not unduly delay the work.

**IV. Miscellaneous Requirements**

**Criminal and Prohibited Activities**

- a. The Program Fraud Civil Remedies Act (31 USC §§ 3801-3812), provides for the imposition of civil penalties against persons who make false, fictitious, or fraudulent claims to the Federal government for money (including money representing grant/cooperative agreements, loans, or other benefits.)
- b. False statements (18 USC § 287), provides that whoever makes or presents any false, fictitious, or fraudulent statements, representations, or claims against the United States shall be subject to imprisonment of not more than five years and shall be subject to a fine in the amount provided by 18 USC § 287.
- c. False Claims Act (31 USC 3729 et seq), provides that suits under this Act can be brought by the government, or a person on behalf of the government, for false claims under federal assistance programs.
- d. Copeland "Anti-Kickback" Act (18 USC § 874), prohibits a person or organization engaged in a federally supported project from enticing an employee working on the project from giving up a part of his compensation under an employment contract.

**American-Made Equipment And Products**

Grantees are hereby notified that they are encouraged, to the greatest extent practicable, to purchase American-made equipment and products with funding provided under this award.

**Increasing Seat Belt Use in the United States**

Pursuant to EO 13043, Grantees should encourage employees and contractors to enforce on-the-job seat belt policies and programs when operating company-owned, rented or personally-owned vehicle.

**Federal Leadership of Reducing Text Messaging While Driving**

Pursuant to EO 13513, Grantees should encourage employees, sub-awardees, and contractors to adopt and enforce policies that ban text messaging while driving company-owned, rented vehicles or privately owned vehicles when on official Government business or when performing any work for or on behalf of the Federal Government.

**Federal Employee Expenses**

Federal agencies are generally barred from accepting funds from a Grantee to pay transportation, travel, or other expenses for any Federal employee unless specifically approved in the terms of the award. Use of award funds (Federal or non-Federal) or the Grantee's provision of in-kind goods or services, for the purposes of transportation, travel, or any other expenses for any Federal employee may raise appropriation augmentation issues. In addition, NRC policy prohibits the acceptance of gifts, including travel payments for Federal employees, from Grantees or applicants regardless of the source.

**Minority Serving Institutions (MSIs) Initiative**

Pursuant to EOs 13256, 13230, and 13270, NRC is strongly committed to broadening the participation of MSIs in its financial assistance program. NRC's goals include achieving full participation of MSIs in order to advance the development of human potential, strengthen the Nation's capacity to provide high-quality education, and increase opportunities for MSIs to participate in and benefit from Federal financial assistance programs. NRC encourages all applicants and Grantees to include meaningful participations of MSIs. Institutions eligible to be considered MSIs are listed on the Department of Education website:

<http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html>

**Research Misconduct**

Scientific or research misconduct refers to the fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. It does not include honest errors or differences of opinions. The Grantee organization has the primary responsibility to investigate allegations and provide reports to the Federal Government. Funds expended on an activity that is determined to be invalid or unreliable because of scientific misconduct may result in a disallowance of costs for which the institution may be liable for repayment to the awarding agency. The Office of Science and Technology Policy at the White House published in the Federal Register on December 6, 2000, a final policy that addressed research misconduct. The policy was developed by the National Science and Technology Council (65 FR 76260). The NRC requires that any allegation be submitted to the Grants Officer, who will also notify the OIG of such allegation. Generally, the Grantee organization shall investigate the allegation and submit its findings to the Grants Officer. The NRC may accept the Grantee's findings or proceed with its own investigation. The Grants Officer shall inform the Grantee of the NRC's final determination.

**Publications, Videos, and Acknowledgment of Sponsorship**

Publication of the results or findings of a research project in appropriate professional journals and production of video or other media is encouraged as an important method of recording and reporting scientific information. It is also a constructive means to expand access to federally funded research. The Grantee is required to submit a copy to the NRC and when releasing information related to a funded project include a statement that the project or effort undertaken was or is sponsored by the NRC. The Grantee is also responsible for assuring that every publication of material (including Internet sites and videos) based on or developed under an award, except scientific articles or papers appearing in scientific, technical or professional journals, contains the following disclaimer:

"This [report/video] was prepared by [Grantee name] under award [number] from [name of operating unit], Nuclear Regulatory Commission. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the view of the [name of operating unit] or the US Nuclear Regulatory Commission."

**Trafficking In Victims Protection Act Of 2000 (as amended by the Trafficking Victims Protection Reauthorization Act of 2003)**

Section 106(g) of the Trafficking In Victims Protection Act Of 2000 (as amended as amended, directs on a government-wide basis that:

“any grant, contract, or cooperative agreement provided or entered into by a Federal department or agency under which funds are to be provided to a private entity, in whole or in part, shall include a condition that authorizes the department or agency to terminate the grant, contract, or cooperative agreement, without penalty, if the grantee or any subgrantee, or the contractor or any subcontractor (i) engages in severe forms of trafficking in persons or has procured a commercial sex act during the period of time that the grant, contract, or cooperative agreement is in effect, or (ii) uses forced labor in the performance of the grant, contract, or cooperative agreement.” (22 U.S.C. § 7104(g)).

### **Executive Compensation Reporting**

2 CFR 170.220 directs agencies to include the following text to each grant award to a non-federal entity if the total funding is \$25,000 or more in Federal funding.

Reporting Subawards and Executive Compensation.

#### *a. Reporting of first-tier subawards.*

1. *Applicability.* Unless you are exempt as provided in paragraph d. of this award term, you must report each action that obligates \$25,000 or more in Federal funds that does not include Recovery funds (as defined in section 1512(a)(2) of the American Recovery and Reinvestment Act of 2009, Pub. L. 111–5) for a subaward to an entity (see definitions in paragraph e. of this award term).

#### *2. Where and when to report.*

i. You must report each obligating action described in paragraph a.1. of this award term to <http://www.fsrs.gov>.

ii. For subaward information, report no later than the end of the month following the month in which the obligation was made. (For example, if the obligation was made on November 7, 2010, the obligation must be reported by no later than December 31, 2010.)

3. *What to report.* You must report the information about each obligating action that the submission instructions posted at <http://www.fsrs.gov> specify.

#### *b. Reporting Total Compensation of Recipient Executives.*

1. *Applicability and what to report.* You must report total compensation for each of your five most highly compensated executives for the preceding completed fiscal year, if—

i. the total Federal funding authorized to date under this award is \$25,000 or more;

ii. in the preceding fiscal year, you received—

(A) 80 percent or more of your annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

(B) \$25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

iii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at <http://www.sec.gov/answers/execomp.htm> .)

2. *Where and when to report.* You must report executive total compensation described in paragraph b.1. of this award term:

i. As part of your registration profile at <http://www.ccr.gov> .

ii. By the end of the month following the month in which this award is made, and annually thereafter.

c. *Reporting of Total Compensation of Subrecipient Executives.*

1. *Applicability and what to report.* Unless you are exempt as provided in paragraph d. of this award term, for each first-tier subrecipient under this award, you shall report the names and total compensation of each of the subrecipient's five most highly compensated executives for the subrecipient's preceding completed fiscal year, if—

i. in the subrecipient's preceding fiscal year, the subrecipient received—

(A) 80 percent or more of its annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

(B) \$25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts), and Federal financial assistance subject to the Transparency Act (and subawards); and

ii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at <http://www.sec.gov/answers/execomp.htm> .)

2. *Where and when to report.* You must report subrecipient executive total compensation described in paragraph c.1. of this award term:

i. To the recipient.



ii. By the end of the month following the month during which you make the subaward. For example, if a subaward is obligated on any date during the month of October of a given year ( *i.e.*, between October 1 and 31), you must report any required compensation information of the subrecipient by November 30 of that year.

d. *Exemptions*

If, in the previous tax year, you had gross income, from all sources, under \$300,000, you are exempt from the requirements to report:

i. Subawards,

and

ii. The total compensation of the five most highly compensated executives of any subrecipient.

e. *Definitions*. For purposes of this award term:

1. *Entity* means all of the following, as defined in 2 CFR part 25:

i. A Governmental organization, which is a State, local government, or Indian tribe;

ii. A foreign public entity;

iii. A domestic or foreign nonprofit organization;

iv. A domestic or foreign for-profit organization;

v. A Federal agency, but only as a subrecipient under an award or subaward to a non-Federal entity.

2. *Executive* means officers, managing partners, or any other employees in management positions.

3. *Subaward*:

i. This term means a legal instrument to provide support for the performance of any portion of the substantive project or program for which you received this award and that you as the recipient award to an eligible subrecipient.

ii. The term does not include your procurement of property and services needed to carry out the project or program (for further explanation, see Sec. \_\_ .210 of the attachment to OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations").

iii. A subaward may be provided through any legal agreement, including an agreement that you or a subrecipient considers a contract.

4. *Subrecipient* means an entity that:

- i. Receives a subaward from you (the recipient) under this award; and
- ii. Is accountable to you for the use of the Federal funds provided by the subaward.

5. *Total compensation* means the cash and noncash dollar value earned by the executive during the recipient's or subrecipient's preceding fiscal year and includes the following (for more information see 17 CFR 229.402(c)(2)):

- i. *Salary and bonus.*
- ii. *Awards of stock, stock options, and stock appreciation rights.* Use the dollar amount recognized for financial statement reporting purposes with respect to the fiscal year in accordance with the Statement of Financial Accounting Standards No. 123 (Revised 2004) (FAS 123R), Shared Based Payments.
- iii. *Earnings for services under non-equity incentive plans.* This does not include group life, health, hospitalization or medical reimbursement plans that do not discriminate in favor of executives, and are available generally to all salaried employees.
- iv. *Change in pension value.* This is the change in present value of defined benefit and actuarial pension plans.
- v. *Above-market earnings on deferred compensation which is not tax-qualified.*
- vi. *Other compensation, if the aggregate value of all such other compensation (e.g. severance, termination payments, value of life insurance paid on behalf of the employee, perquisites or property) for the executive exceeds \$10,000.*