AOE DEPARTMENT SAFETY REVIEW FORM FOR
EXPERIMENTAL RIGS

In the context of this form 'rig' refers to any potentially hazardous piece of equipment whose safe operation requires more detailed instructions and procedures than can be included in the Experimental Workspace Safety Review form for the area in which the rig is housed. Examples include a wind tunnel, laser system, high pressure tank, material testing machine, rotating system.

Before any such rig in the Department of Aerospace and Ocean Engineering is brought into operation, and **at least once per year** thereafter, a copy of this form must be completed, signed and submitted by the responsible faculty/staff member (usually the principal investigator). When an existing rig undergoes modifications which could affect its safety, a new copy of this form must been submitted by the responsible faculty/staff member at that time, and before it is operated again.

Completed forms should be submitted to the AOE Assistant Department Head for Facilities (Michael Philen) and should also be made available to other faculty/staff with relevant expertise, or with direct involvement in the rig or space where it is housed. Any advice resulting from this interaction should be copied to the Assistant Department Head, as well as being transmitted back to the responsible faculty/staff member. Once the responsible faculty/staff member is satisfied that all safety concerns have been met the final version of the form should be signed and submitted and a copy displayed in a prominent position on or adjacent to the rig and on the department safety website. The responsible faculty/staff member may then authorize its operation. Under no circumstances may a rig be operated without a completed, current copy of this form prominently displayed.

Date of form 8/15/23 ..... Form expires (no more than 1 year after form date): 8/15/24 .....

Name of Rig ONR 18-inch Sevik Rotor Rig and 8.5-inch BOR Rotor Rig.....

Workspace where rig is located VTSS room 158, Experimental Aeroacoustics Lab, also Virginia Tech Stability Wind Tunnel.....
Include room, building and name given to the space on the EHS training website.

Faculty/staff member responsible for the rig and its safety William J Devenport/Nathan Alexander .....

Office Address 660/608 McBryde .. Phone 1-4456/1-1152 .. Email devenport@vt.edu / alexande@vt.edu ..

1. An evaluation of the above rig has been performed and the following safety risks have been identified (append details where necessary):

1. **Rotating machinery risks.**
   a. **Intentionally or unintentionally placing any body part in the rotor disk plane during high-speed rotation would result in severe injury.**
   b. **Any fixed article that is placed, or is dropped or propelled, into the rotor plane during operation would likely become a projectile launched across the lab or wind tunnel placing anyone in the vicinity at high risk of injury. It could also cause blades to become detached and also be launched as projectiles.**
   c. **Any loose clothing placed near the rotating parts of the system could become entangled, drawing the wearer into the rotating blade system and resulting in injury.**
   d. **Modifying the moving parts of the rotor system in any way, such as attaching items to the blades or within the hub, without appropriate balancing will cause the rotor system to become unstable at speed. The resulting vibration and mechanical stress could cause the rotor system to move from its mount, to fail, or to propel any loose item or debris across the lab or wind tunnel. This would expose personnel nearby to significant risk of severe injury.**
2. **Risk of electric shock. The motor controller for the rotor system uses a 480V supply. Touching live contacts at this voltage will cause severe injury or death. Incorrect wiring or connections could cause an electrical fire or result in electrocution.**
3. **Risk of lifting injuries or crushing. The rotor system weighs several hundred pounds. Individuals attempting to lift the assembled system alone are likely to suffer injury. If the system were to fall on someone, crushing injuries would likely result.**

2. The following actions have been taken to minimize those risks (append details where necessary):

The risks described above have been minimized by developing and ensuring adherence to safe operating rules and procedures. These are described in attachment 1.

3. A safe operating procedure has been developed (attach the procedure to this form). This includes protective equipment to be worn, whether users may operate the rig alone and, if necessary, precautions to be taken by others working in the same laboratory. The procedure is in a form suitable for posting on the rig.

See attachment 1

4. Check one and include a list: ☐ *The rig may only be operated by the following individuals.*
☒ *The rig may only be operated under the supervision of the following individuals.*
(List individuals here)

Dr. Nathan Alexander, Assistant Professor, AOE Department, Virginia Tech
Jarrod Banks, Szu Fu Huang, Graduate Research Assistants, AOE Department, Virginia Tech

5. The above individuals are all registered on the EHS training website at https://secure.hosting.vt.edu/www.ehss.vt.edu/training/training_report.php and have taken all appropriate safety training courses. Their training is current and is recorded on the EHS website, under the above workspace name. The appropriate safety courses are (list here):

Personal Protective Equipment (PPE) Awareness
HAZCOM RTK
Electrical Awareness
Lockout/Tagout Awareness
Portable Fire Extinguishers

Signature of faculty/staff member responsible for workspace and its safety ..... Date 8/15/23 .....

ATTACHMENT 1
ONR 18-INCH SEVIK ROTOR RIG and 8.5-INCH BOR RIG.
SAFE OPERATING PROCEDURES.

This document describes procedures for users of the two ONR Rotor Rigs in the Stability Wind Tunnel and in Randolph 15D. All authorized users must read this form before beginning work with the rig. Safety around this rig is taken very seriously. This document outlines some identified hazards and procedures that, when followed, my help to reduce risk of injury or damage. Ultimately, however, you the user bear the primary responsibility for your own safety and the safety of others around you.

CONTACT INFORMATION

William J. Devenport, devenport@vt.edu, 231 4456 (Lab Director, Director of the Stability Wind Tunnel)
Nathan Alexander, alexande@vt.edu, 231 1152 (Research Scientist)
Aurelien Borgoltz, aurelien@vt.edu, 231 1959 (Deputy Director of the Stability Wind Tunnel)
Bill Oetjens, boetjens@vt.edu, 231 6752 (Wind Tunnel Engineer)

BACKGROUND

The ONR rotor rigs are designed to spin up to 5000 rpm. At the top speed, the rotor blade tips of the 18-inch rig are moving at about 220mph. The rotors are designed for aerodynamic and aeroacoustic testing in the Stability Wind Tunnel as part of sponsored ONR projects. The systems are also set up also to be bench tested in Randolph 15D.

IDENTIFIED SAFETY RISKS

4. Rotating machinery risks.
   a. Intentionally or unintentionally placing any body part in the rotor disk plane during high-speed rotation would result in severe injury.
   b. Any fixed article that is placed, or is dropped or propelled, into the rotor plane during operation would likely become a projectile launched across the lab or wind tunnel placing anyone in the vicinity at high risk of injury. It could also cause blades to become detached and also be launched as projectiles.
   c. Any loose clothing placed near the rotating parts of the system could become entangled, drawing the wearer into the rotating blade system and resulting in injury.
   d. Modifying the moving parts of the rotor system in any way, such as attaching items to the blades or within the hub, without appropriate balancing will cause the rotor system to become unstable at speed. The resulting vibration and mechanical stress could cause the rotor system to move from its mount, to fail, or to propel any loose item or debris across the lab or wind tunnel. This would expose personnel nearby to significant risk of severe injury.
5. Risk of electric shock. The motor controller for the rotor system uses a 480V supply. Touching live contacts at this voltage will cause severe injury or death. Incorrect wiring or connections could cause an electrical fire or result in electrocution.
6. Risk of lifting injuries or crushing. The rotor system weighs several hundred pounds. Individuals attempting to lift the assembled system alone are likely to suffer injury. If the system were to fall on someone, crushing injuries would likely result.

PROCEDURES FOR OPERATING AND WORKING WITH THE ONR SEVIK ROTOR RIG

The procedures below are in addition to those required for working in Randolph 4P or the Stability Wind Tunnel. Only the trained personnel explicitly named on the safety form, and approved by William Devenport or Nathan Alexander, are authorized to operate the rotor rigs. All operators and assistants working with or around the rig are also required to read and sign this form, and return the signed copy to William Devenport or Nathan Alexander *before* beginning work with the rig. In the following procedures "operation of the rotor rigs" refers to any situation in which a rotating component or components are to be spun using the drive motor, regardless of whether those components comprise the complete rotor system.

1. All laboratory or wind tunnel setups in which the the rigs are to be operated under power must be explicitly approved in advance by William Devenport or Nathan Alexander. Any changes to the configuration, including but not limited to any changes in the rotating part of the system, changes to the system power, changes to the placement of the system or of any protective or other hardware placed around it must be explicitly be approved in advance by William Devenport or Nathan Alexander.
2. Only personnel essential to the test may be present in in the room (be it Randolph 15C or the control room of the Stability Wind Tunnel) during operation of the Sevik Rotor Rig. Lab/control room doors must be closed during operation and signs placed prohibiting entry.
3. Whenever the power plug for the rotating rig is inserted into its power socket a lockout-tag out must be installed on the breaker to prevent the rotor from being placed under power when working in the rotor test area.
4. The rotor may not be placed under power unless the 480V contacts on the controller are securely covered.
5. A minimum of two people must be present in the room when the rig is under power. All people present must have read, signed and returned this form.
6. It is the responsibility of all people present in the room to know the emergency shutdown procedure (below), and to ensure clear paths to the critical items needed for shut down *before* the rig is placed under power.

7. When personnel are operating one of the rigs in an open laboratory, all those present in the room must wear eye protection and hard hats when the rig is under power. For operation in the Stability Tunnel, Lexan shields must be used to create a barrier between the rotor and operators. Ear protection is not required in the Stability Tunnel unless decibel levels exceed standard levels of safety.
8. Users may not operate or assist with the rigs when wearing loose clothing or clothing (such as a tie) that could become entangled.
9. Nothing may be attached to the rotating components of the system without the prior explicit approval of William Devenport or Nathan Alexander.
10. Special precautions for operation of the rigs in the Stability Tunnel
    a. Before operating the rotor system, the Stability Tunnel's Lexan shield system, consisting of a wall of hanging 6x4-foot Lexan panels will be installed on the outside of the port-side anechoic chamber so as to protect all personnel present in the control room and the path to any emergency shut off hardware from any projectile that were to take a direct path from the rotor system. Lexan panels *must* be free to swing to maximize their effectiveness.
    b. All personnel in the control room must be in the area between the wall containing the air-lock door and the Lexan shield when the rotor rig is placed under power.
    c. Any deviations from or modifications to rules 'a' and 'b' above may *only* be granted by William Devenport or Nathan Alexander
11. Special precautions for operation of the rig in the Randolph 15D
    a. Before operating the rotor system, it must be mounted inside the Lexan and sand-bag housing to protect against flying debris. Great care must be taken to ensure there is no possibility of items falling or otherwise entering the rotor plane. The rotor support must be restrained so there is no possibility of the rotor system moving, or inadvertently being moved, during operation.
    b. Signs indicated "Danger: Testing In Progress" must be posted around the test area when testing is in progress, and removed when it is not.

EMERGENCY SHUTDOWN PROCEDURE.

In the event of an emergency, the rotor can be shutdown one of three ways:

c. The ASCII command K can be entered in the rotor control's terminal screen. This command disables the rotor.
d. Shutoff the servodrive's 24V power supply.
e. Shutoff the 480V power to the rotor. The plug itself should never be removed. Cut power by turning off the breaker.

These methods should not be used for normal operation. Emergency shutdown could cause rapid deceleration of the rotor rig and may result in damage to the experimental apparatus.

ATTACHMENT 2
ONR ROTOR RIGS.
SIGNATURE.

I have read and understand all the above risks, rules, restrictions and procedures described in the AOE Department Experimental Facility Safety Review form for the ONR Rotor Rigs, including attachment 1, “Safe Operating Procedures” . I have been provided with a copy of these documents

Name of rig operator or assistant_____

Signature _____

Date_____