HOT CHECKOUT FOR 12 GeV AT JEFFERSON LAB*

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Abstract

A new hot checkout process was implemented at Jefferson Lab for the upgraded 12 GeV accelerator. The previous process proved insufficient in the fall of 2011 when a fire broke out in a septa magnet along the beam line due to a lack of communication about the status of systems. The improved process provides rigorous verification of system readiness thus protecting property while minimizing program delays. To achieve these goals, a database and web application were created to maintain an accurate list of machine components and coordinate and record verification checks by each responsible group. The process requires groups to publish checklists detailing each system check to encourage good work practice. Within groups, the process encourages two independent checks of each component: the first by a technician, and a second by the group leader. Finally, the application provides a dashboard display of checkout progress for each system and beam destination of the machine allowing for informed management decisions. Successful deployment of the new process has led to safe and efficient machine commissioning.

INTRODUCTION

Hot checkout (HCO) is the process by which all required accelerator hardware and software systems are tested for safe and effective accelerator operation prior to beam startup. Checks are performed while the machine is locked up and energized. The goal of HCO is to reduce program interruptions due to faulty or misconfigured hardware and software and to minimize the likelihood of a failure that damages equipment. Such an event occurred at Jefferson Lab (JLab) on October 14 2011 after a small number of preliminary 12 GeV upgrade changes had been put into place. Two septa magnets overheated and ignited a fire causing both program delays and property damage (Fig. 1). The low conductivity water valves for the magnets were closed and the thermal switches on the box supply that normally would trip on an over-temperature fault failed because the switch was disabled via a jumper. The root cause was determined to be inadequate communication of machine readiness and poor work control practices [1].

More extensive changes to the machine, and thus more complicated hot checkouts during the upcoming 12 GeV era were going to need strict oversight. At the time of the magnet fire there was no formally documented procedure for HCO. The previous approach relied on a single individual, the so-called Restoration Coordinator (RECO) to obtain verbal confirmation from the multiple group leaders of the readiness of their systems. This approach was appropriate for shorter downs where few changes were made to the machine as the RECO did not have the authority or resources to ensure the groups responsible for the machine were meticulously verifying component status. A committee was formed to address the shortcomings of the RECO and produce a more stringent process and associated software tool [2].

Figure 1: Septa magnet MYR7S03 fire damage.

PROCESS OVERVIEW

The new HCO process can be organized into three stages: setup, upkeep, and signoff. The initial setup stage involves documenting components and their properties and only has to occur once. The upkeep stage is on-going and ensures the data put in place during setup remains up-to-date. Upkeep tasks often coincide with accelerator maintenance periods and include preparation for each signoff period. The signoff stage entails checking component readiness and occurs immediately before resuming beam operations after an extended accelerator maintenance period. In practice the signoff stage is usually done twice a year: once before the fall run and again before the spring run.

Scope

The rigorous HCO is reserved for use following extended maintenance periods of a week or more The HCO process is not used during machine running to track downtime as the HCO process is not designed to be a repair log. There is a separate process and tool for tracking downtime at JLab during machine operation [3]. The HCO process is analogous to an aircraft pre-flight checklist process: once the plane is in the air the checklist is no longer useful.

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Furthermore, the HCO process focusses primarily on protecting equipment and reducing operational downtime; it coexists with the personnel safety system (PSS) certification process which remains the primary means for protecting people.

Setup

During setup all of the components in the machine that require checkout must be identified and classified. Components are organized into collections labeled as systems. Systems are further organized into a hierarchical tree of categories based on type (Fig. 2).

Components are placed together in a system if they are of a common type, share the same set of responsible groups, and use the same verification checklist. Placing components into systems helps responsible groups search and filter the large list of components, allows tracking of checkout progress based on systems, and avoids explicitly assigning an often redundant set of responsible groups to each component.

Two other properties of each component are established during setup: the region the component is located in and the set of beam destinations the component participates in. Both of these properties provide additional filters for searching for components and tracking progress. Providing the ability to determine readiness based on beam destination is particularly important since one or more of the experimental halls are often not included in the program and therefore are not needed to be ready for operations when other halls are.

Every group must publish a checklist for each system of components that it is responsible for. The checklist documents how the group determines that each component in the system is ready for beam operations. The checklists are web-accessible by all staff members.

Upkeep

One of the biggest upkeep tasks is ensuring that signoffs are downgraded when needed. Downgrades can occur at any time during the hot checkout process and by any staff member. When one group downgrades a component, the action will cascade to subsequent groups and require them to re-validate their prior checkout. Downgrades are also done administratively during maintenance periods when components are replaced, moved, or repaired. The JLab task tracking system, ATLis, is reviewed by management prior to a signoff period to determine what needs to be downgraded and re-checked.

On-going upkeep of component lists, component beam destination participation, responsible group assignments, checklists, and system and category organization is also necessary. Responsible groups must notify administrators if components are added, removed, or modified. Geographic integrators also play an important role in ensuring the list of components and their attributes is up to-date.

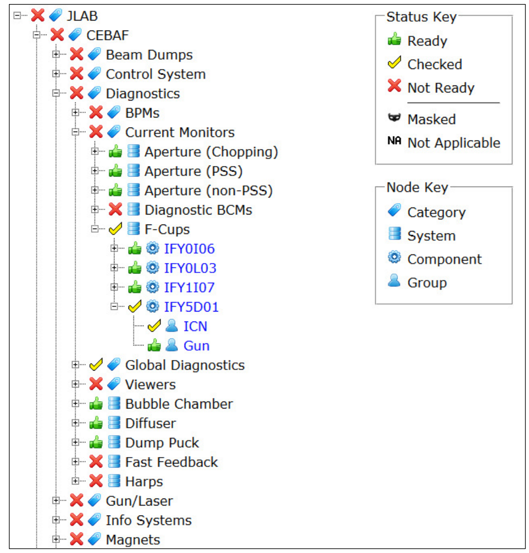

Figure 2: The component hierarchy as viewed from the HCO web application.

Signoff

Signoffs are done by responsible groups and require at least two checks per group. Each group indicates whether a component is ready, checked, or not ready. The typical flow is for a technician to verify a component and mark it as checked. A group leader then only marks a component as ready after conferring with the technician or after putting a second set of hands on the component. Only a group leader is authorized to mark a component as ready. Signoffs are recorded with a digital signature, timestamp, and optional user comment. Any user can make a comment without changing the signoff status. The history of all signoffs is recorded in the database and exposed via a web-interface for easy auditing.

Category readiness is determined by aggregating the readiness of the systems and components it contains. A component is ready once all responsible groups have signed off on the component as being ready. A system is ready once all of the components which it contains are ready. A category is ready only once all of the systems which it contains are ready. Given ready = 1, Checked = 2, and Not Ready = 3; the status calculation can be generalized as the following recursive algorithm: the status of a given node in the tree is the maximum status of its child nodes and in the base case of a component leaf node the status is set by the maximum of the responsible group signoffs. This hierarchical status roll-up allows users to quickly drill down to components which are not ready. Component attributes can be used to filter readiness for a particular beam destination, region, or responsible group.

There are two special signoff statuses: masked and not applicable (N/A). The operations director is given the administrative authority to mark as masked certain components which are not needed for safe machine operation. This is useful for example when a diagnostic that is not required for the upcoming run is non-

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functional. The N/A signoff is used in situations where subsets of components in a system belong to different responsible groups. The non-responsible group signs N/A on the components it does not check. Masked components and N/A signoffs are ignored when computing the system/category status roll-up.

DATABASE

The new HCO process relies on readiness information stored in a centralized relational database. The initial list of component names was obtained from the JLab CEBAF Element Database (CED) [4]. The CED contains approximately 86% of the HCO components (7,403 of 8,644 as of September 2015). The remaining 14% (1,241) of components were obtained by soliciting group leaders and geographic integrators to verify the list of components and fill in any gaps. The components which require checkout, but are not in the CED include items that are not part of the EPICS control system, such as HVAC and other facilities items. Scripts were written to keep the databases in sync and are run periodically, especially before a checkout period.

WEB APPLICATION

The HCO web application provides a readiness dashboard for operators, management, and responsible groups to track checkout progress. The components in the machine are presented using a hierarchical tree widget that allows filtering by beam destination, region, and responsible group.

The application also provides graphical reports, a checklist repository, and a form for groups to sign off on individual components or collections of components. The application requires a published checklist for every system from each responsible group. The software will not permit a group to signoff components until the checklist for the systems is published. Further, the application maintains a list of group leaders and enforces that only they are authorized to signoff as ready.

A setup page provides forms for administrators to add, remove, and edit components and their properties, as well as manage beam destinations, regions, group leaders, and systems/categories.

INITIAL USAGE

The HCO process and software were utilized for the first time in September 2013 with the commencement of the 12 GeV upgrade commissioning. Figure 3 illustrates how as the HCO process progressed and new regions of the machine were verified as ready, project milestones were rapidly achieved. In fact, the accelerator division program goals for 2014 were completed five months ahead of schedule [5].

PROCESS PARTICIPATION

The HCO process has been a demonstrated success at involving a wide swathe of the lab personnel in a cooperative effort. To date, there have been 19,789 signoffs by 132 users across 43 groups. A common goal of achieving 12 GeV upgrade project milestones coupled with the recent collective memory of the YR magnet fire helped imbue staff with an early sense of common purpose. The early involvement of as many people as possible in the process design helped in creating buy-in and cooperation. Encouraging continuous feedback and improvement kept everyone engaged and has led to a better process.

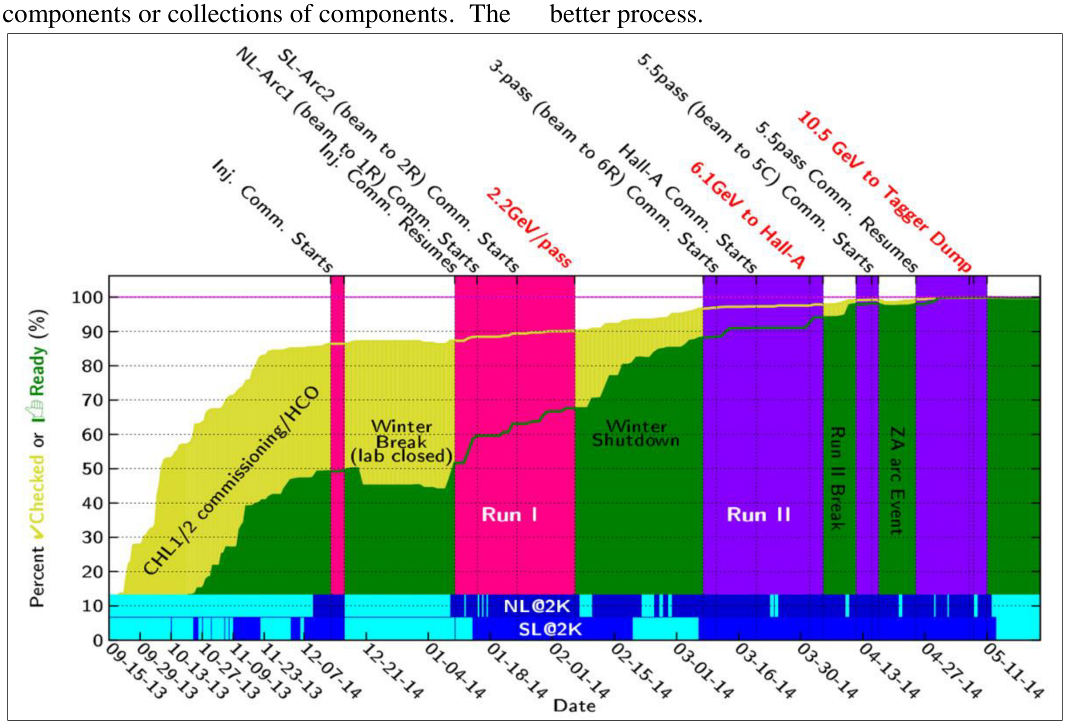

Figure 3: 12 GeV Commissioning Run I and II Progression. The yellow and green areas trace progress of verifying each component as checked and then ready. (Illustration reproduced with permission courtesy of A. Freyberger).

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SUPPORTING PROJECTS

Several supporting projects were developed in parallel with the hot checkout process. The JLab wireless network infrastructure was upgraded to cover nearly the entire underground tunnel and a half dozen tablet computers were made available for technician use. The mobile computers allow technicians to view checklists and sign off on components while standing directly in front of the component in question. The Accelerator Bypassed-Interlocks Log (ABIL) project helps operators and technicians communicate bypassed component status using a digital log of bypassed components and physical tags placed directly on bypassed components.

CONCLUSION

We have developed a systematic method of checking, recording, and sharing machine readiness. The new process and software tool guides communication among operators, technicians, group leaders, geographic integrators, and management decision makers. The web-based tool provides a dashboard with real-time status reporting. The new process and tool contributed to a smooth 12 GeV upgrade project commissioning.

ACKNOWLEDGMENT

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