GRUBISA MILLWRIGHT SERVICES

FISH LAKE 2

Generator Overhaul And Cleanup

jerico

7/30/2012



Inspection procedures, rigging for removal, removal of the flywheel for repair, thrust damage repair, photos of the various stages, and re-installation

Initial inspection (as found)

Removed the outlet piping and recorded runner clearances.
Top .043”
Rhs .026”
Bot .025”
Lhs .018”
Turbine bearing seal measurements.
I.B.
Top .015”
Rhs .013”
Bot .-14”
Lhs .011”
O.B.
Top .018”
Rhs .018”
Bot .018”
Lhs .015”
Generator bearing seal measurements (inboard)
I.B.
Top .054”
Rhs .035”
Bot .013”
Lhs .009”
O.B.
Top .039”
Rhs .015”
Bot .031”
Lhs .017”
Generator bearing seal measurements. (Outboard)
I.B.
Top .019”
Rhs .018”
Bot .015”
Lhs .014”
O.B.
Top .025”
Rhs .025”
Bot .027”
Lhs .017”
Total thrust was .023”. (Taken at the exciter end of the generator)

Removed fly wheel/brake cover and got photos of the extreme erosion on the wheel (below).





All portions of the brake had this erosion. This is after the repair.

Removed thrust pads and upper cap on the Mitchell (thrust) bearing. Found indication of contamination (dirt) and thrust. (note photos)









The thickness of the thrust ring on the turbine shaft was measured:
Outside wear area 1.491”
Worn surface 1.489”
This means that we will have to machine the ring in place, removing .002” using stones and lapping compounds. The babbited portions of the assembly will have to be sent out and redone, adding the .002” that must be removed from the thrust ring.

We suspect the thrust is a result of the eroded flywheel and constant braking due to the brake valve passing because of seat and plug damage. This problem was evident in the last inspection and subsequently repaired without knowing the true cause. As a result we recommend that when doing the initial checks, the flywheel cover be removed with the TIV open to check whether the brake valve is passing. We also recommend that when cleaning the bearing housings, we use a vacuum (not rags) to do final cleaning as the internal surfaces in the housing are porous and prone to trapping contaminants and particulates.

The remaining bearing caps were removed and the side clearances taken.
Mitchell bearing side measurements.

Rhs	.005”@1”	.005”@3/8”	Lhs
	.005”@1”	.005”@1/8”	

Generator bearing side measurements (inboard side)

Rhs	.004”@ ¼”	.004”@1/8”	Lead wire (top crush)
	.004”@1/8”	.004”@1/4”	fore .012” mid .012” aft .012”

Generator bearing side measurements (outboard side)

Rhs	.005”@1”	.005”@1/8”	Lead wire (top crush)
	.005”@1¼”	.005”@1/8”	fore .015” mid .018” aft .021”

Generator air gap		Exciter air gap	
Rhs	.162”	Rhs	.052”
Top	.175”	Top	.052”
Bot	.125”	Bot	.033”
Lhs	.125”	Lhs.	.041”

Procedure for Generator Removal

Prior to the generator removal, the exciter, its base, the O.B. bearing, and pedestal must be removed. The exciter was sent in to be cleaned and checked as part of the general scope. All these components were cleaned and inspected prior to reinstallation. All bases and surfaces were stoned to remove any surface anomalies.

Tool and Rigging List

2	20 foot nylon slings
4	24 inch nylon slings
2	3 ton come-alongs
1	1 1/2” shackle
2	adjustable stands
2	dial indicators
1	machinist level

Attach the 1 ½” shackle to the “d” ring on the stator

- Choke rotor shaft ends with the 24” slings
- Attach come-alongs to rotor slings
- Attach come-alongs to the 24” slings from hook
- Set up dials (1 on the stator foot and 1 on the stator bearing surface)

- Take up stator load until you get .004” lift on the dial
- Take up rotor load (both ends evenly) until you get .004” lift on the dial
- Adjust hook elevation and come-alongs until both loads are suspended
- Jack shaft out of the flywheel spigot until clear (750”)
- Re-adjust rigging until all is level
- Remove entire assembly from the building
- Set stator on the skids and torque
- Set rotor on the adjustable stands and adjust until air gap is even all around
- Rig up the 20 foot slings to the rotor shaft ends
- Take up the rotor load until the stands can be removed
- Move rotor until the windings protrude past the center line
- Re-set on the adjustable stands
- Re-rig 20 foot slings on the rotor center line (choke)
- Remove rotor

Note: Prior to the lift all bearing and winding surfaces must be protected from impact with 1/16” thick garlock gasket material, fastened with duct tape to prevent movement.

Reversal of the above method should be used to re-install components.

Installation of the Flywheel

Prior to setting the generator in place the flywheel must be inserted into the flywheel casing. Once the generator assembly is set in place, the flywheel can be fastened to the turbine shaft, by inserting the two take up bolts and pulling the spigot together (there should be never seize on all surfaces prior to this). Ensure throughout this stage, that the runner slides back into the turbine housing without binding. The generator rotor shaft can then be fastened to the flywheel using the coupling bolts, carefully drawing the shaft into the spigot. At all times throughout this step, the distance from the shaft end and flywheel should be checked and maintained, using feeler gauges to ensure parallel draw up preventing offset and galling of the two surfaces. After take up, the coupling bolts must be torqued to their maximum using a 2”socket and long breaker bar. After final torque has been achieved, a feeler gauge must be inserted between the flywheel faces and shaft faces on both sides of the flywheel to ensure full contact all around. On assembly it was noted that there was .0015” space on the generator rotor flange to flywheel, this clearance was only evident for a small, outer portion of the flange (approximately ¾” of a 4” radius).

Bearing repair.
The thrust pads were slightly modified to reflect the removal of material from the thrust ring (.002”). We also had the Babbitt Company add .004” to the thickness to reduce the total thrust from .023” to .019”, and incorporate oil wedge onto the leading edge of the

pad, (note photos). We also incorporated an oil wedge into the bottom section as well. As you can see from the photos there is a significant improvement to the surfaces. You will see from the photos that the Mitchell bearing bottom section was also repaired. The O.B. generator bearing had some striations on the leading edge that was repaired, (note photo). The remaining bearings (generator inboard) were in good shape and required cleaning only. In the future we recommend that instead of simply wiping out the housings, we vacuum them, as the inner surfaces are porous and tend to trap particulates and dirt.

Top sections as found



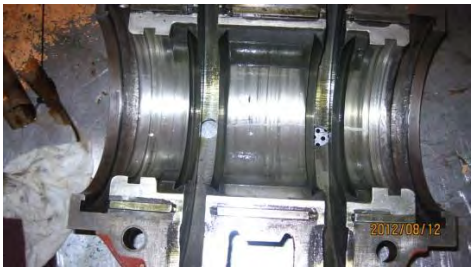
After repair. Note oil wedge.



Bottom section after repair.



As found



After repair



As found



After repair



Final clearances after reassembly

Turbine bearing seal clearances.

	I.B.
Top	.016”
Rhs	.014``
Bot	.014``
Lhs	.012``
	O.B.
Top	.020``
Rhs	.018``
Bot	.018``
Lhs	.020``

Generator bearing seal clearances. (I.B.)

	I.B.
Top	.038``
Rhs	.o18``
Bot	.024``
Lhs	.014``
	O.B.
Top	.036``
Rhs	.018``
Bot	.040``
Lhs	.022``

Generator bearing seal clearances. (O.B)

	I.B.
Top	.026``
Rhs	.013``
Bot	.018``
Lhs	.016``
	O.B.
Top	.029``
Rhs	.023``
Bot	.021``
Lhs	.013``

Mitchell bearing side clearances.

Rhs	.005”@1/2”	.005”@1”	LHS
	.005”@1”	.005”@1/2”	

Generator side clearances. I.B. Lead wire clearances (top crush)

Rhs	.004”@3/4”	.004”@3/4”	LHS	fore .012” mid .012” aft .012”
	.004”@3/4”	.004”@1”		

Generator side clearances. O.B. Lead wire clearances (top crush)

RHS	.005”@3”	.002”@3/4”	LHS	for .016” mid .019” aft .019”
	.005”@3”	.002”@1/2”		

Total shaft run out was .000”@ generator I.B. bearing and .001”@ generator O.B. bearing.

Total thrust was .019” (taken at the exciter end)

Generator air gap.		Exciter air gap.	
Top	.250”	Top	.046”
Rhs	.254	Rhs	.038”
Bot	.256”	Bot	.032”
Lhs	.252”	Lhs	.040”

Proximeter probe was set at .020”

Summary

After assembly, the unit was run up to 600hz and loaded up to generate 480KW, all the while monitoring the bearing and winding temperatures. There was much more air movement through the windings, thus increasing our cooling. There was a slight leak on the governor control lever which was subsequently repaired. Bearing temps came up as per normal and reached running temp after 2 hours. The machine was monitored for 12 hours and all parameters were within operating spec. We adjusted the seals on the flywheel housing to eliminate contact and ran the unit at full capacity for 24 hours. In that time the inboard generator bearing reached the alarm temperature once (65degrees C) but did not exceed this temperature. The water brake was applied with a dial indicator on the O.B end of the generator shaft and no noticeable thrust was produced. We checked the thrust bearings and pads after the initial 12 hour run, but found no indication of excessive thrust. The housing was then vacuumed and refilled with fresh oil for the final run. It was noted that the new TIV was passing and it was recommended that there be a bore scope inserted to see where the leak was.
While the generator outboard bearing was being checked we found the clearances to be fairly small, (note above red) so we tried to adjust the pedestal, but became bolt bound. It was decided to run the unit and carefully monitor the bearing, but after 24 hours of run time there was no noticeable difference in the bearing temps.

Fish Lake #2 Inspection

Inspection started on Sept. 20, 2011.
Start up date on Sept. 23, 2011.

Turbine.

Removed the outflow piping and inspected the runner. It was found to be in excellent shape with no evidence of erosion or cavitation.





Outer clearances were:

Top	.041"
Left	.029"
Right	.024"
Bot.	.016"

Shaft runout was .000"
Turbine shaft packing was still soft with plenty of adjustment still available.
Cooling lines were checked and screens were removed and cleaned.

Turbine Main Bearing.

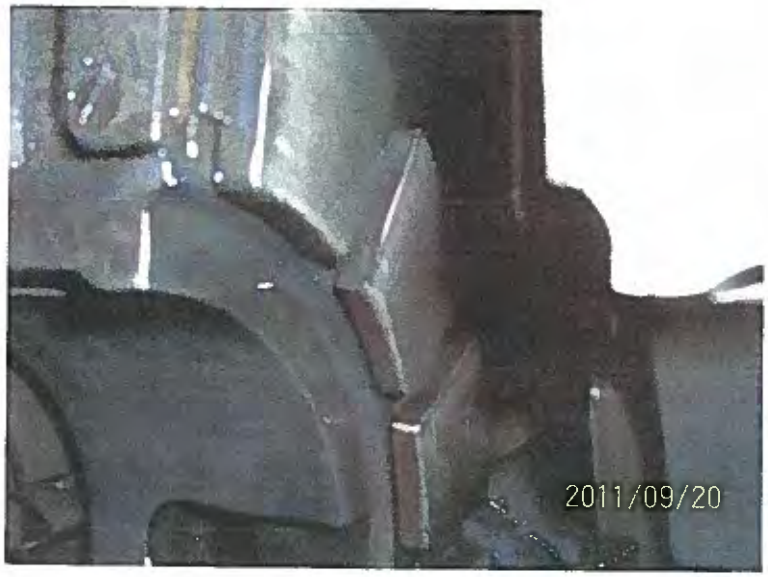
(thrust)

Checked seal clearances:

Top	.015"
Left	.015"
Right	.008"
Bot.	. 0135"

After removing the bearing cover we found excessive wear on the thrust ring and pads. There was some indication of heat and what appeared to be lack of lubrication.

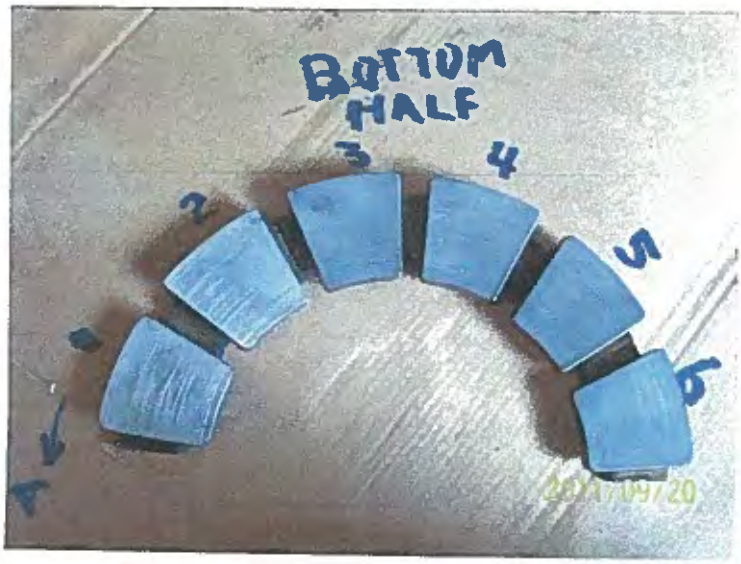






Before repair







Before repair.



New wheel

As you can see, the wheel and pads have some damage on them. The thrust pad carrier shows signs of heat and minor impact damage (as per the photo), this caused the pads to "wick" the oil film away from the thrust area. The thrust package was removed and cleaned. The carrier was stoned and the impact damage repaired. This allowed the thrust pads to move more freely, thus allowing the oil to distribute evenly across the entire thrust area. The wheel was stoned to remove the high spots and even out the thrust area.

When comparing the old wheel with the new one it is clear that this was a problem in the past. The wear pattern is the same on both (compare with photo below.)



Old wheel



. After repair.



After repair.

The entire bearing was cleaned and re-installed using STP synthetic oil for pre-lube.

The clearances are:	Total thrust,	.021"
	Side clrc.,	.004" to one inch, all six points.
	Vert. Clrc.,	.017 fore. .016 aft. (taken with lead wire.)
Turbine bearing cover seal clrc.,		top .015", left .015", right .008", bot. .0135". (turbine side)
		top .017", left .014", right .013", bot. .019" (water brake side)
Generator inboard bearing seal clrc.		top .061", left .031", right .027", bot. .010" (water brake side)
		top .038", left .021", right .021", bot. .052" (generator side)
Generator inboard bearing clrc.		left side fore .004", aft .004 to 3/8"
		right fore .004", aft .004" to 3/8"
Top clrc. (with lead wire)		fore .010", mid. .009", aft .0095"

Housing was cleaned and flushed before re-assembly.

Generator outboard bearing seal clrc.	top .030", left .030", right .025", bot. .030" (generator side)
	Top .028", left .025", right .027", bot. .032" (exciter side)
Generator outboard bearing clrc.	Left side fore .004", aft .004" to 3/8"
	Right fore .005", aft .005" to 2.00"
Top clrc. (with lead wire)	fore .018", mid .018" aft .0165"

Generator inboard and outboard covers were removed for inspection. The internals of the generator were extremely dirty (note photos).



Inboard



Inboard



Inboard



Outboard



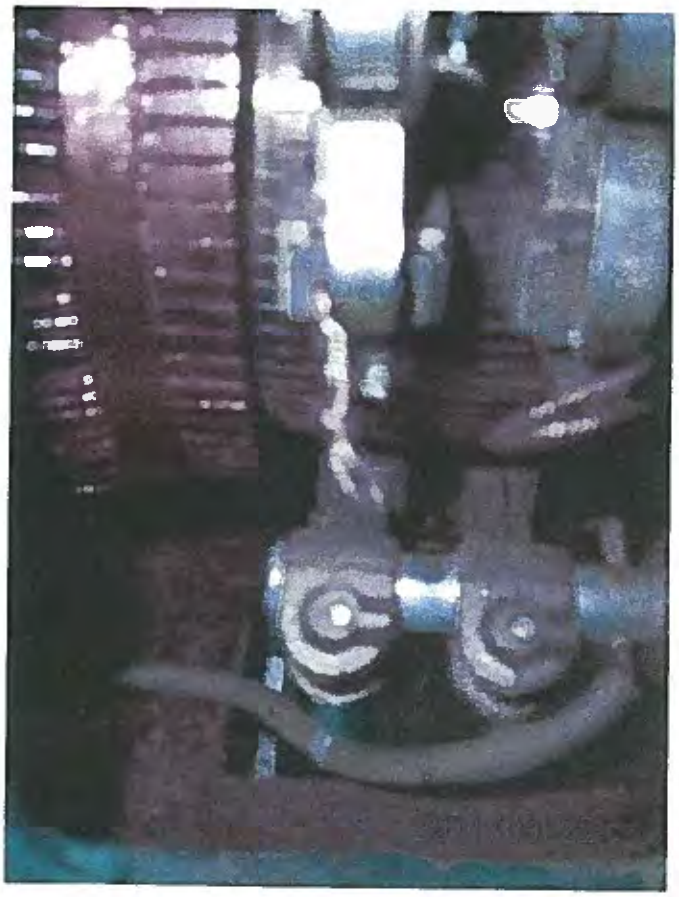
Outboard



Outboard

We recommend that the generator be dismantled and cleaned. It was suggested that dry ice blasting be used if possible to eliminate any chance of damage and to reduce debris after cleaning. Client will follow up recommendation (check with Marc Liederman). Air gap was taken, all were .235" to .248". There was minor damage to the windings on the outboard side of the generator, customer reviewed and repaired with insul tape and glyptol.

The exciter was inspected and found to be in good shape with minor wear on the carbons. (note photos).





Air gap was taken looking aft, the readings are top left .056", mid .061", right .056".
Bot. Left .052", mid .054", right .057".

Proximity probe was set at .020".

Summary

The generator looks to be in very good condition, and after the repairs to the thrust pad carriers, there should be no further thrust issues. The vacuum settings of -6"hg was discussed as a possible factor in the thrust problem, but bears some further research. The water brake has some minor cracks on the leading edges at two locations on the wheel, which in the future could break away and cause balance issues. There is a lot of erosion on this wheel as well, so balance may already be an issue. We recommend that the wheel be removed and sent out for sandblasting, NDT, repair, and balancing. The generator must be cleaned, as discussed earlier, and can possibly be addressed at the next shutdown. All the coupling bolts were inspected and checked for tightness, all showed no wear and were fully torqued. The bearing housings were filled with new oil (Terresso 46), and all sight glasses were repaired.

Inspection done by: Gerald Mussell
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Grubisa Millwright Services
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Field Service Report
HYDRO CONTROLS DIVISION

CUSTOMER NAME:	ATCO - Yukon Electric
SITE NAME / LOCATION:	Fish Lake 2/ Whitehorse, Yukon, Canada
CUSTOMER PO#:	YECL54546
REPORTED TO:	Peter McCollum/ Plant Maintenance
CONTACT PHONE AND EMAIL:	867-334-2576/ Peter.McCollum@atco.com
ADD'L CONTACT NAMES / PHONE / EMAIL:	Travis White
	Roger Floyd
SERVICE ENGINEER:	Bill Eberman
SERVICE DATE(S):	7/14 - 7/18/14
TYPE OF EQUIPMENT:	Gilkes Size "D" Governor circa 1954
ADDITIONAL GOVERNOR INFORMATION:	Giljet Control
HYDRAULIC POWER UNIT:	Self-contained, three belt-driven integral gear pump.
HYDRO TURBINE MAKE / MODEL:	Gilkes/ Horizontal Francis
TURBINE HEAD, SPEED, HP:	200 ft., 1200 RPM, 800 BHP
APPLICATION:	Power Generation
GENERATION OUTPUT:	812 KVA/ 480 to 490 KW

REASON FOR SERVICE CALL

"About 2 years ago the customer began to have some intermittent problems with the unit where they would manually spin the unit up to 1200 rpm and then transfer control of the unit to the governor. Sometimes the governor would control the unit and sometimes it would not. The unit would slow down and the customer was unable to synchronise to the grid. Maintenance Plant personnel have had parts of the governor apart to try to find a problem but it looks clean. They are having problems with the Fish Lake 2 governor again, except all of the time. When adjusting speed off-line or changing load on-line the pendulum lever has to be tapped or bumped to get the governor to respond."

Scope of work: Inspect governor operation; troubleshoot overall operation of Gilkes Governor.

DAILY ACTIVITY LOG

Monday, July 14, 2014
Traveled to Whitehorse, Yukon, Canada.

Tuesday, July 15, 2014
When I arrived the unit had been shutdown and secured due to a tubing leak associated with the electro-hydraulic shutdown assembly. Upon removing the the tube it was found that the ferrule had come loose from the OD of the copper tubing and this was the source of the leak. Note: In the shutdown condition, solenoid de-energized, this tubing carries the entire constant pressure flow from the underside of the Distributing Valve plunger to sump, allowing the plunger to fall and port oil to close the gates. Using what was on hand, we made up a new discharge line of sufficient capacity from braided steel fuel hose and fittings.

After the power pole switches were closed in (they were open due to output transformer testing that had been conducted the previous day), we were then able to open the TIV, water-up and start the unit for preliminary observation. After reaching speed-no-load manually, the shutdown solenid was manually lifted and reset, the unit was transfered into the governor mode and the handwheel mechanism retracted. An effort was made to slightly lower the speed reference (during the synchronizing process), the speed plummeted instead and the unit tripped out on Low Voltage; the unit adversely reacted just as they had reported the condition to us.

The unit was secured and disassembly began. During the remainder of the day, the governor was disassembled down to and including the distributing valve. The hydraulic shutdown assembly was also completely disassembled and overhauled.

Wednesday, July 16, 2014
Cleaned and inspected parts. Upon inspecting the belt-driven centrifugal ballhead it was found that (in my opinion) there was too much vertical lost motion in the mechanism. Normally this can be removed through use of the thrust adjustment at the top of the mechanism. Attempted to remove the lost motion with available fine and coarse adjustments available to no avail due

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Field Service Report
HYDRO CONTROLS DIVISION

to its limited detented positions. It had been brought to my attention that the customer had a spare ballhead assembly as well as a spare ballhead drive shaft assembly. Since it seemed like the proverbial "rainy day" we decided to install these new components; the equipment wasn't getting any younger.

Also, during the component inspection period it was noted that there was wear to the brass upper dashpot spring retainer (hole through which the plunger rod operates and well as some deformity of its cap). It was decided to record its dimensions for duplication at a later date rather then delaying the work that we were peforming.

Performed limited re-assembly.

Thursday, July 17, 2014
Completed the re-assembly process. Oiled pivot points and started the unit. The unit was now responsive to speed and speed reference changes and the customer was happy with the results. I was released from the project. I'd like to thank Pete for meeting me at the airport and making a company truck available to me since I wasn't able to lease a car for my use there. The last input that I received (from Grant Horte C.E.T.) was that "The guys said the unit works a 100% better".

Friday, July 18, 2014
Returned Home.

RECOMMENDATIONS

CRITICAL CONCERNS: None.

GENERAL RECOMMENDATIONS: Gave some thought to the dashpot wear and the misalignment noted after re-assembly. This may be corrected by loosening the mounting hardware at the base of the Pendulum (centrifugal ballhead) Gear Box and turn it slightly to bring everything on the floating lever back into its proper alignment (avoid further wear to the brass upper dashpot spring retainer)

OBSERVATIONS: Prior to my arrival there was some talk of replacing or converting this governor system sometime in the future. Fish Lake 1 had destroyed itself (turbine impulse runner and consequently the case had flown apart) and Canyon Hydro had replaced everything including the building the year before this visit. As I see it, there are two ways to go:

A. Low Pressure Conversion - Remove everything from atop the sump and interface with the cylinder via a PLC-controlled EHI manifold with the same footprint as the existing distributing valve. Remove the ballhead and pump belts, provide a speed signal using proximity probes, direct drive the pump w/ a coupled motor and add an accumulator bottle to the pump output.

B. High Pressure Conversion - Remove governor, interface with the existing bracket that supports the regulating shaft via a new stanchion with small high pressure cylinder that includes a position feedback device. Install an HPU w/ accumulator bottle(s), servovalve, timing valves, etc. Install a cubicle, wall or panel-mounted governor enclosure containing PLC and auxiliary electrical devices.

******* END OF REPORT *******

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Trip Report: Whitehorse, Yukon
Yukon Electric
Fishlake Hydroelectric Generating Station

Subject: AVK Series 54, DN450

Problem:
Valve reported to be leaking. Leakage started at date of installation. The valve was reported to be leaking 10 gallons per minute.

Installation:
The AVK valve is used as a turbine intake valve at the Fish Lake hydroelectric power plant. The power plant is capable of producing 500 kW with a head pressure of 85 to 95 psi. The AVK S54 DN450 gate valve is equipped with special flange drilling to match the drilling of the original valve, which was installed around 1950. The valve is equipped with a bypass. The valve is also equipped with an electric motor actuator for automatic open and close during plant operation, supplied by others. The actuator is an AUMA actuator, part number SA14.1-54B-GK16.2(4-1A)-AM01-0.

Site Visit – Pre Meeting:
A pre meeting to discuss the problem was held 27 August, 2013. During the meeting we discussed our methodology to determine the cause of the leakage and solve it. The difficulties of valve installation were discussed. The upstream and downstream flanges are significantly misaligned. The flanges of the installation had a .400-inch vertical offset and a 0.125-inch layback (the top of the flange was 0.125-inch further away from the matching flange than the bottom). Because of this misalignment a specially machined spool piece to fill the gap in the lay length between the old and new valves was manufactured, which was to compensate for the layback and vertical offset. See picture 1 below.



Picture 1

In Picture 1, upstream is to the right, downstream is to the left. The custom spool piece is the steel flange just to the upstream side the blue AVK valve. When the valve was installed, it was first bolted to the flange on the downstream side. Then the spool piece was custom machined to fit the gap between the valve and the pipe flange on the upstream side.

Site Visit:
We arrived on site around 8:00 am on the morning of 28 August, 2013. First, the flange bolts on the downstream side of the valve were loosened slightly. Loosening the bolts reduced the leakage from the above mentioned 10 gal/minute to approximately one drop per second. From this, it was determined that the offset and layback of the flange, regardless of the custom spool piece, was inducing strains on the body of the valve and causing the seats to warp, increasing the leakage of the valve.

The downstream flange was retightened, which caused the rate of leakage to increase to 300-450 ml/minute.

The valve was disassembled to ensure there was no damage to the seats and that there were no obstructions in the valve preventing it from fully closing. Upon disassembly the seats were found to be in excellent condition, and there were no obstruction in the valve. See Pictures 2 and 3.



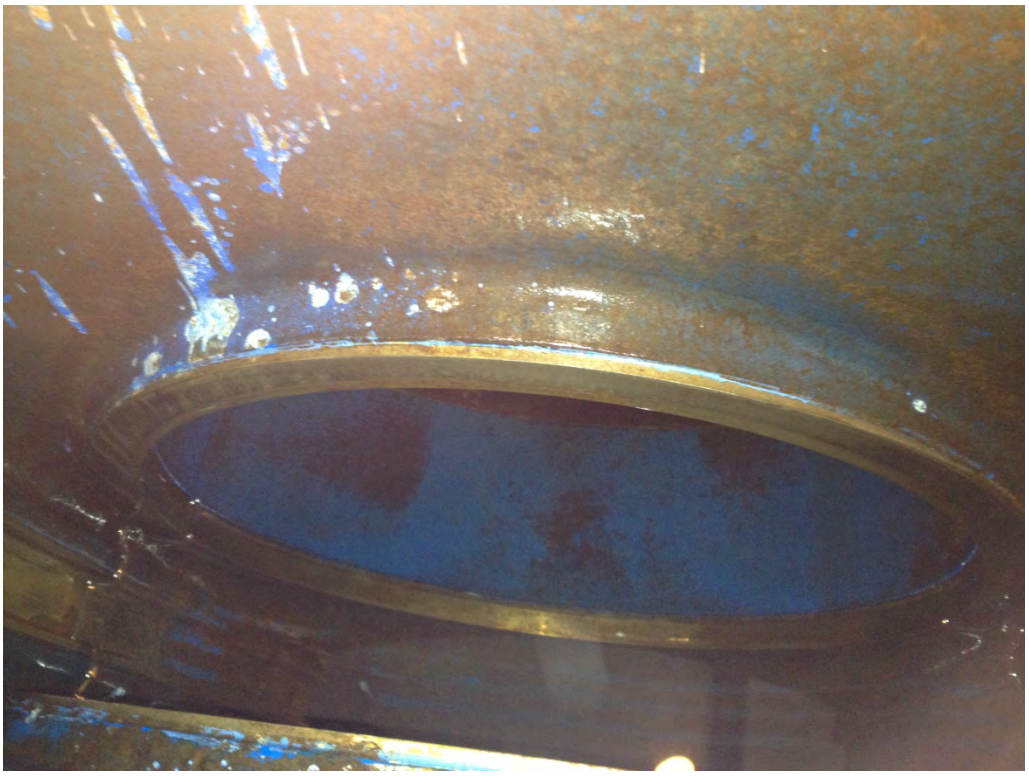
Picture 2

Picture 2 shows the seats on the downstream face of the valve. The seats have been polished with a cloth to remove any deposits from the lake water. The seats were not damaged.



Picture 3

Picture 3 shows the seats on the upstream face of the valve. They are also undamaged. Please note that the valve gate is not corroded, it is just dirt and silt that looks like it is rust.



Picture 4

Picture 4 shows the valve body seats. They are also in excellent condition. Please note that what looks like corrosion is dirt and silt from the lake water going through the valve. The buildup was less than 0.5mm thick. The blue lines at the bottom of the valve are from running my fingers along the valve body checking for obstructions.

After inspection the valve was reassembled and the line was charged to make sure there were no leaks. The pressure test was successful.

Conclusion:
After valve reassembly and pressure test, the valve was closed. It was still leaking, but at a much lower rate of 300 to 450 ml per minute.

This leakage is not ideal, but was determined to be from the misalignment of the flanges and not a fault of the valve. The customer, Yukon Electric, accepts this explanation.

John Wilber, P.E.
American AVK
VP – Engineering Services