**Exhaust-manifold cracking**

You can be sure problems exist when both the user group and the OEM have panel discussions on the same subject at different times during the same meeting. On Tuesday, Vice Chairman Russ Snyder moderated a panel in a user-only session devoted to exhaust cylinder/manifold cracking and repair experiences. Three users made short presentations; Q&A was lively.

The following day, five Siemens experts were available to answer questions after Scott Harrell presented on the same subject. Summaries of key Siemens presentations are compiled in the last section of this report; complete details are available to qualified 501F owner/operators on the OEM’s Customer Extranet Portal (CEP). If you do not have access to this valuable information resource, and believe you qualify, contact Dawn McCarter at dawn.mccarter@siemens.com for information on how to register.

Cracking in the exhaust cylinder and exhaust manifold sections of the GT (Fig 12) is not difficult to believe when you consider that more than 1100 lb/sec of turbine exhaust gas at about 1100°F is tearing through the aft end of the machine at nearly mach speed, and that most of these engines stop and start on a daily basis. Talk about thermal cycles.

Mention was made during both the user and Siemens sessions of broken struts, cracking of components, and general material distress in the exhaust cylinder, and cracking in several areas of the exhaust manifold.

Given the conditions, users enter outages prepared to make repairs. However, you get the sense while listening to them that they are frustrated because cracks often occur in the same location during each production run and have to be repaired every outage. Long-lasting repairs often are an elusive objective.

However, some progress apparently has been made in at least one area by third-party vendor KE-Burgmann USA (KEB), Hebron, Ky. A user on Snyder’s panel focused on cracking of the exhaust manifold just ahead of the aft or downstream flange that bolts to the expansion joint frame (refer again to Fig 12).

According to the speaker, most 501Fs have suffered cracks in this area, which is probably why the room was full and virtually everyone seemed to be paying attention. He added that several units also have found cracking at the opposite end of the manifold, just downstream of the upstream flange.

Next, the user described the cracking in his unit and how KEB—well known for its large, high-temperature expansion joints—did the repair. The editors dug into the details with Paul Schubert, the company’s field service manager, who has more than four decades of applicable welding experience. He said weld repairs are a natural extension of KEB’s expans-
sion-joint work on the exhaust end of the machine.

The first question that a user might ask: How will I know when cracking occurs? That’s easy: Insulation is burned by the hot gas escaping through the crack and it turns white as shown in Fig 13.

A second question might be: How concerned should I be if a crack develops? Also easy: very. Safety is an obvious concern. The speaker said the last crack his unit experienced went almost all the way around the exhaust manifold. He showed a film clip of the escaping gas; that got everyone to sit up straight.

Another concern is that any escaping gas contains CO and NOx at much higher levels than would be found downstream of the emissions control systems incorporated into the heat-recovery steam generator. According to this user, cracks in the exhaust system can open wide and it may be possible to exceed emissions levels specified in your environmental permit.

Thus, there are one or more reasons to repair a crack as quickly as possible. However, if you’re in the middle of a run when demand is high you might not be able to take the machine out of service for a repair that can take up to a week to do correctly. Unfortunately, no one has yet reported on a quick fix that can get you by in the short term.

Fig 14 shows just how wide some cracks can open up. The photo also illustrates a failed attempt at a quick fix from the outside of the exhaust manifold. A series of steel “tiles” were welded in place to “plug” the large open area while accommodating the expansion and contraction associated with daily starts on the unit. High-temperature refractory was worked into voids, held in place by lath-like clips easier to see in Fig 15, a photo taken on the inside of the manifold section. This “fix” lasted only a few hours.

A majority of plant personnel seem to believe cracking at the aft end of the exhaust manifold can be traced, at least in part, to the use of relatively thin plate for the manifold (5/16 in.) together with a massive exhaust flange (more than 2 in. thick).

This flange has 132 bolts to fasten the exhaust manifold to the expansion-joint frame and flow liner. The nuts—hidden by the expansion-joint frame—are prone to backing off during GT operation. When this happens the bolts work their way out of the flange and the loose exhaust flange tries to break off from the exhaust manifold.

The “seal-weld” fix shown in Figs 15 and 16 joins the flow liner to the exhaust flange thereby preventing exhaust gas from leaking out between the flange and expansion joint. Note that the purpose of the flow liner is to direct hot gas over the flange. It is not fastened on the downstream side to accommodate expansion.

What usually happens next is that the stress created by the seal weld initiates a crack about 2 in. upstream. The crack shown in Figs 15 and 16 was from 5/8 to ¾ in. wide and extending more than 300 deg around the exhaust manifold.

The way KEB approaches this repair is to first remove the expansion joint (Fig 17). This requires unbolting both the exhaust flange and the flange on the round-to-square transition piece on the downstream

16. Bolt to left of ruler is backing out of the flange in this close-up of a section of the crack shown in Fig 15. Note that the crack is only about 2 in. from the seal weld.

Downstream exhaust manifold flange bolts together with both the upstream frame for the expansion joint and the flow liner

Repair includes relocating nuts to outside the exhaust-manifold flange and tack-welding bolt heads inside

Downstream exhaust-manifold flange

Round-to-square transition piece

Upstream frame for expansion joint

Exhaust manifold

Flow

Weld repair on outside of large crack

Downstream exhaust-manifold flange

Press the cold button to remove the clip of the escaping gas; that got everyone to sit up straight. A film clip of the escaping gas; that got everyone to sit up straight.

This flange has 132 bolts to fasten the exhaust manifold to the expansion-joint frame and flow liner. The nuts—hidden by the expansion-joint frame—are prone to backing off during GT operation. When this happens the bolts work their way out of the flange and the loose exhaust flange tries to break off from the exhaust manifold.

Drain line Welding cables

Downstream exhaust flange (right) is breaking off from exhaust manifold (left)

Expansion joint goes here; has been removed

Downstream exhaust flange bolts together with both the upstream frame for the expansion joint and the flow liner

Round-to-square transition piece

Upstream frame for expansion joint

Repair includes relocating nuts to outside the exhaust-manifold flange and tack-welding bolt heads inside

Downstream exhaust-manifold flange

Pressure

Weld repair on outside of large crack

Exhaust manifold

Flow

Weld repair on outside of large crack

Downstream exhaust-manifold flange

17. Welders will grind out the crack on the outside and weld it closed after the strap shown in the next photo is installed on the inside.

18. Segmented stainless steel strap is welded over the crack on the inside surface of the exhaust manifold (left).

19. Exhaust flange joint is remade after welding is complete. Note nuts are now on the outside and accessible to plant personnel for retightening when necessary (right)
side of the expansion joint. Next, the upstream exhaust manifold flange is unbolted from the exhaust cylinder. Then the exhaust manifold is pushed back toward the engine about 8 in. to gain access to the crack on both sides of the cylindrical section.

Preparations complete, a Type-347 stainless steel strap 2 in. wide × 0.375 in. thick is welded over the crack on the inside surface of the manifold (Fig 18). The strap is installed in segments to allow for expansion. Then the crack on the outside surface is ground out and welded as shown in Fig 19. Welding done, a new expansion joint is installed and the joints remade using new fastening hardware—with the nuts on the outside this time and bolt heads tack-welded on the inside.

The user speaking about this repair procedure said his units were near the end of their second production run with no sign of gas leakage. Previously no repair had lasted longer than one production run.