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ENGINEERING SUPPORT PROGRAM

WO-LT-0021

Selected NEPS Electrical Transmission Line Field Investigations

September 21, 2011

This publication was produced for review by the United States Agency for International Development. It was prepared by Tetra Tech, Inc.

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September 21, 2011

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Re: WO-LT-0021 Selected NEPS Transmission Line Field Investigations Final Report

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Enclosed is the final report for WO-LT-0021 Selected NEPS Transmission Line Field Investigations.

Please let me know if you have any questions or comments.

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AFGHANISTAN ENGINEERING SUPPORT PROGRAM

WO-LT-0021
Selected NEPS Electrical Transmission Line Field Investigations

September 21, 2011

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1.0 Executive Summary

This report documents the findings of the Field Investigations as directed under Task 2 of WO-LT-0021 Statement of Work (SOW). The Field Investigations were conducted by a field electrical engineer with support from Afghan engineering staff in early July 2011. Under Task 2 the Field Investigations were to include the following:

A. **Assessment of destroyed Sheberghan to Mazar-e-Sharif 110 kV line**
B. **NEPS connection to the Mazar-e-Sharif Fertilizer Plant**
C. **Pul-e-Khumri to Chimtala 220 kV transmission line conductor type verification**
D. **Naibabad to Pul-e-Khumri 220 kV transmission line conductor type verification**
E. **Hairatan border to Uzbekistan 220 kV transmission line conductor type verification**

The inspection started in the Pul-e-Khumri (PeK) substation up to the source of the 220kV through Uzbekistan. The inspection continued west from Naibabad to Mazar-e-Sharif and surrounding substations and transmission facilities.

A summary of the observations and findings are as follows:

A. **Assessment of destroyed Sheberghan to Mazar-e-Sharif 110 kV line**
The Sheberghan 110kV transmission system was visited and data was collected concerning visible conductor size, structure type and visible condition of insulators. The transmission line between the Mazar-e-Sharif substation and the Sheberghan substation is not in use, but the concrete structures are still in place. The conductor is broken and down in practically every span, and the supporting hardware is in poor condition. However, a portion of the transmission structures and insulators are currently in use to provide distribution voltage to the northern section of Mazar-e-Sharif.

B. **NEPS connection to the Mazar-e-Sharif Fertilizer Plant**
The Kud Bergh thermal power plant substation and associated transmission system was investigated for incorporation of surplus generation into the NEPS system. The recommendation of a new substation constructed into the existing crossing of the Sheberghan 110kV system and the 35kV system to the town of Balkh is recommended.

C. **Pul-e-Khumri to Chimtala 220 kV transmission line conductor type verification**
The purpose of the field investigation of the NEPS 220kV system and substations was to de-energize the in-service transmission lines to measure the outside diameter of the installed conductor while inspecting the ends of the conductors to determine stranding composition. This is the most reliable method for determining the physical diameter and the stranding characteristics of the installed conductor.

Unfortunately, the transmission system was not able to be de-energized and there was no equipment nor trained personnel available to physically measure the size of the installed conductor. Furthermore, the conductor dead-ends used to terminate the conductor to the towers at the substation entrance are closed, compression type fittings. These fittings completely cover the conductor ends therefore, the conductor stranding of the installed conductor could not be verified. However, scrap conductor from the PeK to Chimtala transmission line was located at the PeK substation and confirmed by the substation engineer that this was the conductor installed on the line. The line was field measured and verified that it was made up of 54 aluminum strands and 7 steel which indirectly confirms that the conductor is indeed Zebra type.

D. Naibabad to Pul-e-Khumri 220 kV transmission line conductor type verification

As was the case of the PeK to Chimtala line, the field engineer was not able to arrange for a shutdown of the line to directly measure the conductor size. A piece of scrap conductor was located at the Naibabad substation and confirmed by the substation engineer that it was the conductor type installed on the transmission line. The conductor was measured and found to have 26 aluminum strands and 7 steel strands and equates to a Squab type which is listed on the Plan and Profile drawings for this line. This confirms indirectly that the transmission line has been constructed with the Squab conductor.

E. Hairatan border to Uzbekistan 220 kV transmission line conductor type verification

A piece of scrap conductor was located at the Naibabad substation and confirmed by the substation engineer that it was the conductor type installed on the Naibabad to Hairatan transmission line. The conductor was measured and found to have 26 aluminum strands and 7 steel strands and equates to a Squab type which is listed on the Plan and Profile drawings for this line. This confirms indirectly that the transmission line has been constructed with the Squab conductor.

1.1 AMU River Crossing

One additional request was received from USAID to include assessment of alternatives for a new 110 kV transmission line crossing over the AMU River. As a result, the river crossing was investigated to develop alternatives for this additional high voltage river crossing of the Amu River. Two approaches were investigated. The first approach would be to design a new aerial crossing east of the existing river crossing. The second option would be to install underground cable from a new tower location on the Afghanistan side of the river west to the rail bridge (Friendship Bridge) attach conduits to the bridge and then east from the Uzbekistan side of the river crossing to the substation.

2.0 Introduction

POWER Engineers operating under a subcontract with Tetra Tech has been tasked with an on-site field review of the transmission facilities, lines, and structures in the northern area of Afghanistan and to verify conductor sizes for each of the transmission lines associated with the substations investigated in the region.

After a 7-day field visit of multiple substations, transmission line inspections, and conductor analysis between July 1st and July 7th by one of POWER Engineers' Professional Engineers it was clear that the physical inspection of the installed transmission conductors was not going to be possible. The lack of aerial equipment, journeymen linemen, and adequate grounding jumpers would not allow the safe physical measurement of the installed conductors. However, it was possible to identify scrap aerial cable located within the substations and close proximity of the transmission circuit in question for the purpose of conductor measurements and identifications. These were also verified by substation operations and maintenance staff to be the conductors in use.

3.0 Present Situation

3.1 Pul-e-Khumri Substation (N35.974554, E68.713788)

Figure 1 – Aerial View of Pul-e-Khumri Substation.

The substation is a 220kV main and transfer high voltage bus scheme complete with bus coupler and a single 220kV tap to a 220kV to 20kV power transformer. The substation appears to be in good working order and condition.

Notable conditions:

Kunduz 220kV transmission circuits #1 and #2 are open in the substation. There is no electrical energy being received from or delivered to Kunduz over these 220kV transmission lines.

Naibabad 220kV transmission lines are installed over two 220kV lines identified as circuits #1 and circuit #2. Each circuit is double conductor per phase. Circuit #2 is energized and delivering electrical energy from Naibabad over this circuit at 220kV. However, Circuit #1 is not connected to the 220kV switchgear bus system inside the substation. The Naibabad transmission circuit #1, physically disconnected from the 220kV system, is energized at 20kV and being used as a distribution feeder for the Samangan Province. The source for the 20kV circuit is provided through the Pul-e-Khumri 220/20kV power transformer.

Kabul 220kV transmission circuits #1 and #2 are single conductor per circuit and both circuits are closed and delivering electrical energy to the Chimtala substation.

The single line diagram depicts the electrical configuration of the substation, as configured during the substation inspection on July 2nd, 2011.

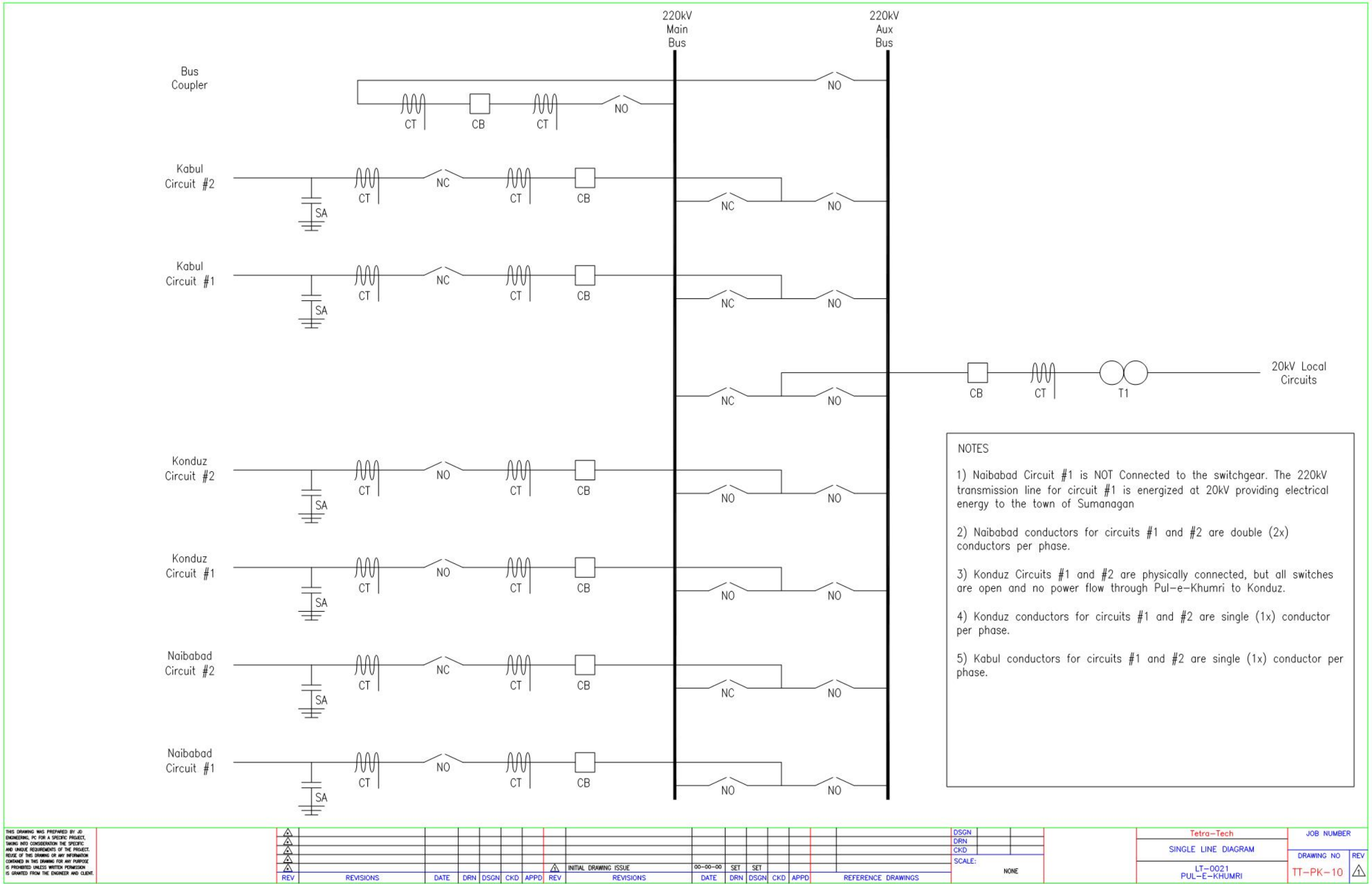

Figure 2 - Single line diagram depicting electrical configuration of the Pul-e-Khumri substation.

3.1.1 Pul-e-Khumri Transmission Conductors

The goal of the field investigation to the Pul-e-Khumri substation was to have the in-service transmission lines de-energized, grounded, and then physically measure the outside diameter of the installed conductor while inspecting the ends of the conductors for the stranding composition. Unfortunately, the transmission system was not able to be de-energized and there was no equipment nor trained personnel available to physically measure the size of the installed conductor. Furthermore, the conductor dead-ends used to terminate the conductor to the towers at the substation entrance was a closed, compression type fitting. These types of fittings physically cover the conductor ends and the conductor stranding of the installed conductor could not be verified (see Figure 5).

Fortunately, there was a hand reel of scrap conductor under, or next to, some of the substation terminal towers for each transmission circuit entering the substation. Each scrap conductor was documented by photographs and the diameter of the scrap conductor physically measured with a micrometer. The substation Engineer, Nemat Sherzab, confirmed the scrap conductor is the same conductor used for each transmission line.

Naibabad Scrap Transmission Conductors

Measurement #1	28.72mm
Measurement #2	28.72mm
Measurement #3	29.26mm

Physical counting of the steel and aluminum composition of the conductor was the following:

- 7 Strands Steel
- 54 Strands Aluminum

Figure 3 - Conductor

Based upon the physical diameter measurement of the conductor and the steel-aluminum stranding composition, the most probable transmission conductor type for the Naibabad two conductors per phase, two circuit transmission line, is the British conductor, code name ZEBRA aluminum conductor steel-reinforced, 54 strands aluminum to 7 strands steel, overall diameter 28.62mm, according to the Midal Catalog Conductor Data Sheet (see appendix A).

Kabul Scrap Transmission Conductors

Measurement #1	28.65mm
Measurement #2	28.62mm
Measurement #3	29.32mm

Figure 4 – Kabul Conductor

Physical counting of the steel and aluminum composition of the conductor was the following:

- 7 Strands Steel
- 54 Strands Aluminum

Based upon the physical diameter measurement of the conductor and the steel-aluminum stranding composition, the most probable transmission conductor type for the Kabul single conductor per phase, two circuit transmission line, is the British conductor, code name ZEBRA aluminum conductor steel-reinforced, 54 strands aluminum to 7 strands steel, overall diameter 28.62mm, according to the Midal Catalog Conductor Data Sheet (see Appendix A).

Kunduz Scrap Transmission Conductors

There was no available scrap transmission conductor under the Kunduz transmission line into Pul-e-Khumri. No data was available to collect on the Kunduz transmission line.

Figure 5 - Typical Conductor Dead-ends

3.1.2 Pul-e-Khumri Transformers

The transformer nameplate data collected:
Manufacturer: ABB, 2007
Capacity: 13/16MVA ONAN/ONAF
Frequency and temperture rise: 50Hz and 55°C
Voltages: 220kV/20kV/10kV (HV/LV/TV)
Taps and Impeadance: Tap 1 – 10.91%Z, Tap 7 – 10.70%Z, Tap 13 – 10.65%Z

3.2 Naibabad Substation (N36.817042, E6767.378855)

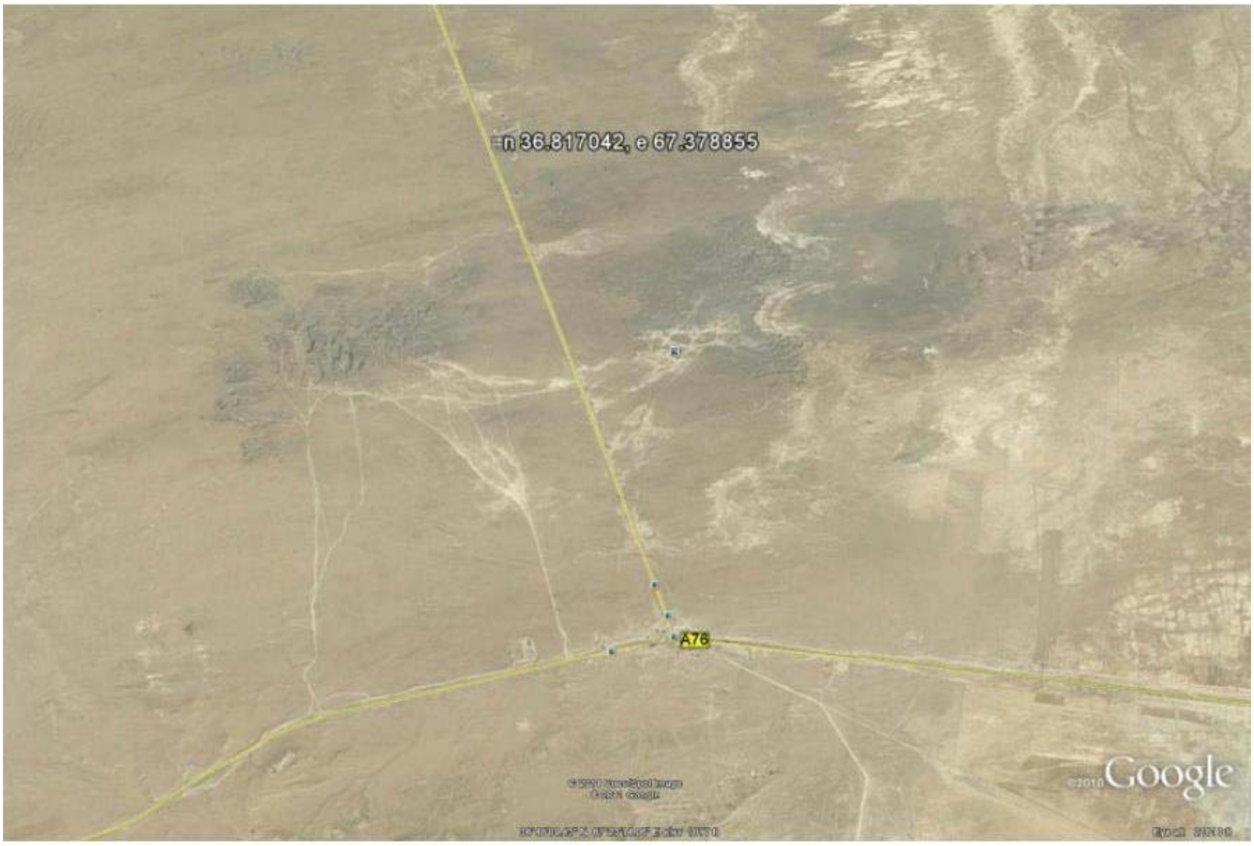

Figure 6 – Aerial view of Naibabad Substation

The Naibabad substation is a transmission switchyard with a 220kV main and transfer high voltage bus scheme complete with bus coupler. There is no power transformation within the switchyard. The substation appears to be in good working order and condition. There is on-going substation construction for the addition of three reactors. The sizes of the reactor are 25, 25, 10 MVAR and were scheduled to be online by the end of July 2011.

Notable conditions are the following:

Naibabad 220kV transmission switchyard single source is from the Hairatan transmission circuit that is through a substation in Uzbekistan. The lines are installed over two (2) 220kV single conductor per phase circuits identified as circuits A and circuit B. There are four (4) 220kV transmission circuits leaving the substation. Two circuits provide electrical energy to the Mazar-e-Sharif substation and two circuits to Pul-e-Khumri substation. Mazar-e-Sharif transmission circuits are single conductor per phase. Mazar-e-Sharif circuit B is not physically connected to the switchgear and is not energized and open in the substation. Pul-e-Khumri transmission circuits are double (2) conductors per phase for each circuit. Pul-e-Khumri circuit B is not physically connected to the switchgear and is not energized and open in the substation. The single line diagram shows the electrical configuration of the substation, as configured during the substation inspection on July 3rd, 2011.

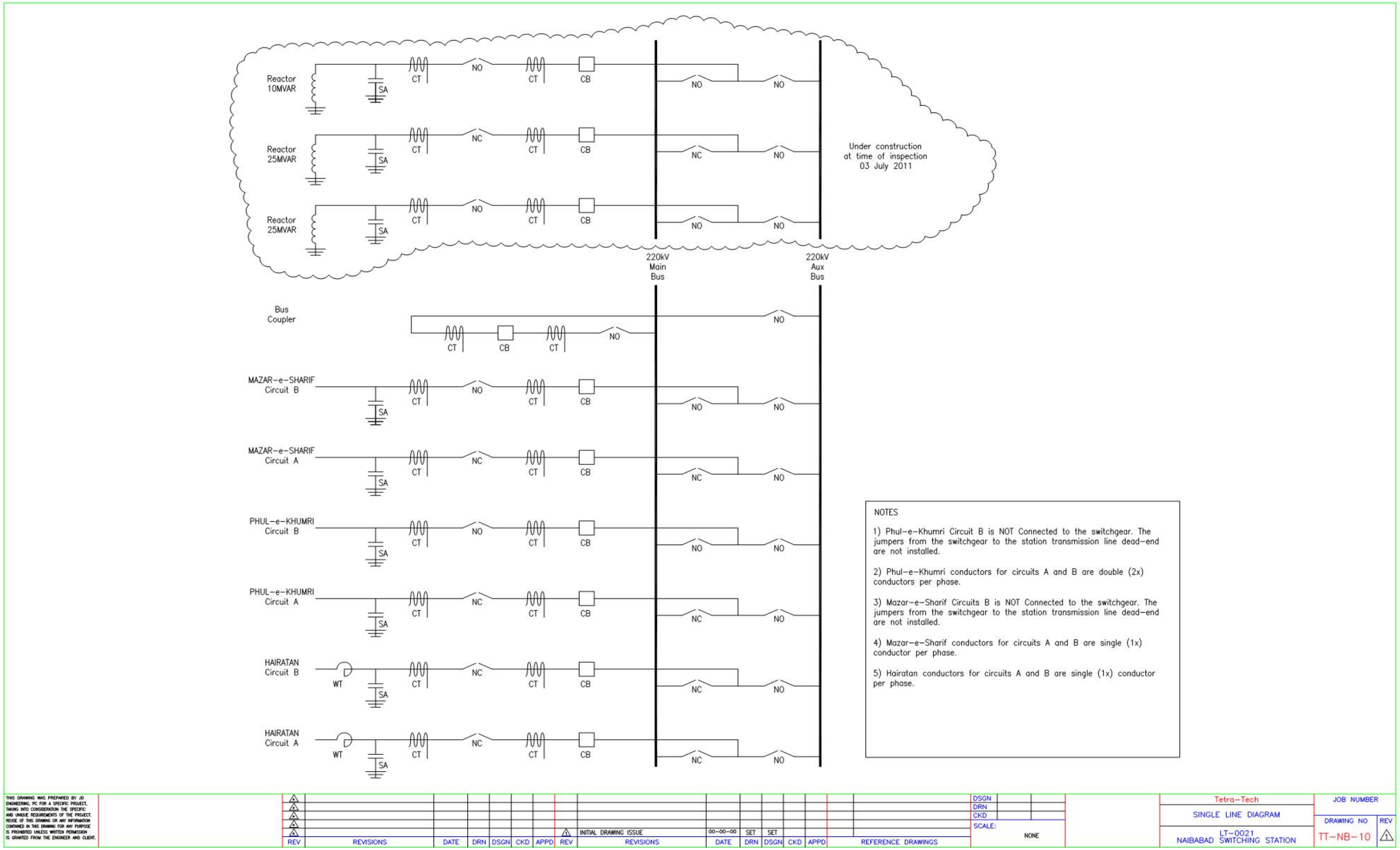

Figure 7 – Single Line Diagram depicting electrical configuration of the Naibabad substation.

3.2.1 Naibabad Transmission Conductors

The goal of the field investigation to the Naibabad substation was to have the in-service transmission lines de-energized, grounded, and then physically measure the outside diameter of the installed conductor while inspecting the ends of the conductors for the stranding composition. Unfortunately, the transmission system was not able to be de-energized and there was no equipment nor trained personnel available to physically measure the size of the installed conductor. The conductor dead-ends used to terminate the conductor to the towers at the substation entrance at Naibabad are identical to the dead-ends used in Pul-e-Khumri. Thus, the conductor stranding of the installed conductor could not be verified.

Fortunately, there was scrap conductor under, or adjacent to, the substation terminal towers for each transmission circuit entering the substation. Each scrap conductor was documented by photographs and the diameter of the scrap conductor physically measured with a micrometer. The substation Manager Edi Muhammad confirmed the scrap conductor is the same conductor used for each transmission line.

Hairatan Scrap Transmission Conductors

Measurement #1	26.57mm
Measurement #2	25.00mm
Measurement #3	24.80mm

Physical counting of the steel and aluminum composition of the conductor was the following:

- 7 Strands Steel
- 26 Strands Aluminum

Figure 8 – Hairatan Conductor

Based upon the physical diameter measurement of the conductor and the steel-aluminum stranding composition, the most probable transmission conductor type for the Hairatan single conductor per phase, two circuit transmission line is code name SQUAB aluminum conductor steel-reinforced, 26 strands aluminum to 7 strands steel, overall diameter 24.51mm, according to the Midal Catalog Conductor Data Sheet (see appendix A).

Pul-e-Khumri Scrap Transmission Conductors

Measurement #1	24.89mm
Measurement #2	25.17mm
Measurement #3	25.09mm

Figure 9 – Pul e Khumri Conductor

Physical counting of the steel and aluminum composition of the conductor was the following:

- 7 Strands Steel
- 26 Strands Aluminum

Based upon the physical diameter measurement of the conductor and the steel-aluminum stranding composition, the most probable transmission conductor type for the Pul-e-Khumri double (2) conductor per phase, double (2) circuit transmission line, is code name SQUAB aluminum conductor steel-reinforced, 26 strands aluminum to 7 strands steel, overall diameter 24.51mm, according to the Midal Catalog Conductor Data Sheet (see Appendix A).

Mazar-e-Sharif Scrap Transmission Conductors

Measurement #1	24.53mm
Measurement #2	24.38mm
Measurement #3	24.59mm

Figure 10 Mazar e Sharif Conductor

Physical counting of the steel and aluminum composition of the conductor was the following:

- 7 Strands Steel
- 26 Strands Aluminum

Based upon the physical diameter measurement of the conductor and the steel-aluminum stranding composition, the most probable transmission conductor type for the Mazar-e-Sharif (MeZ) single conductor per phase, two circuit transmission line is code name SQUAB aluminum conductor steel-reinforced, 26 strands aluminum to 7 strands steel, overall diameter 24.51mm, according to the Midal Catalog Conductor Data Sheet (see appendix A).

Although the diameter of the cables measured varies with the inconsistencies within the scrap conductor, the measurements were not taken at the same location on the cable. The diameter measurements were taken at approximately 1 meter intervals when enough scrap conductor was available. Nevertheless, in all instances the conductor measurements were taken at different locations on the scrap cable.

3.2.2 Naibabad Transformers

There are no power transformers installed at the Naibabad substation.

3.3 Mazar-e-Sharif Substation (N36.735043, E67.146710)

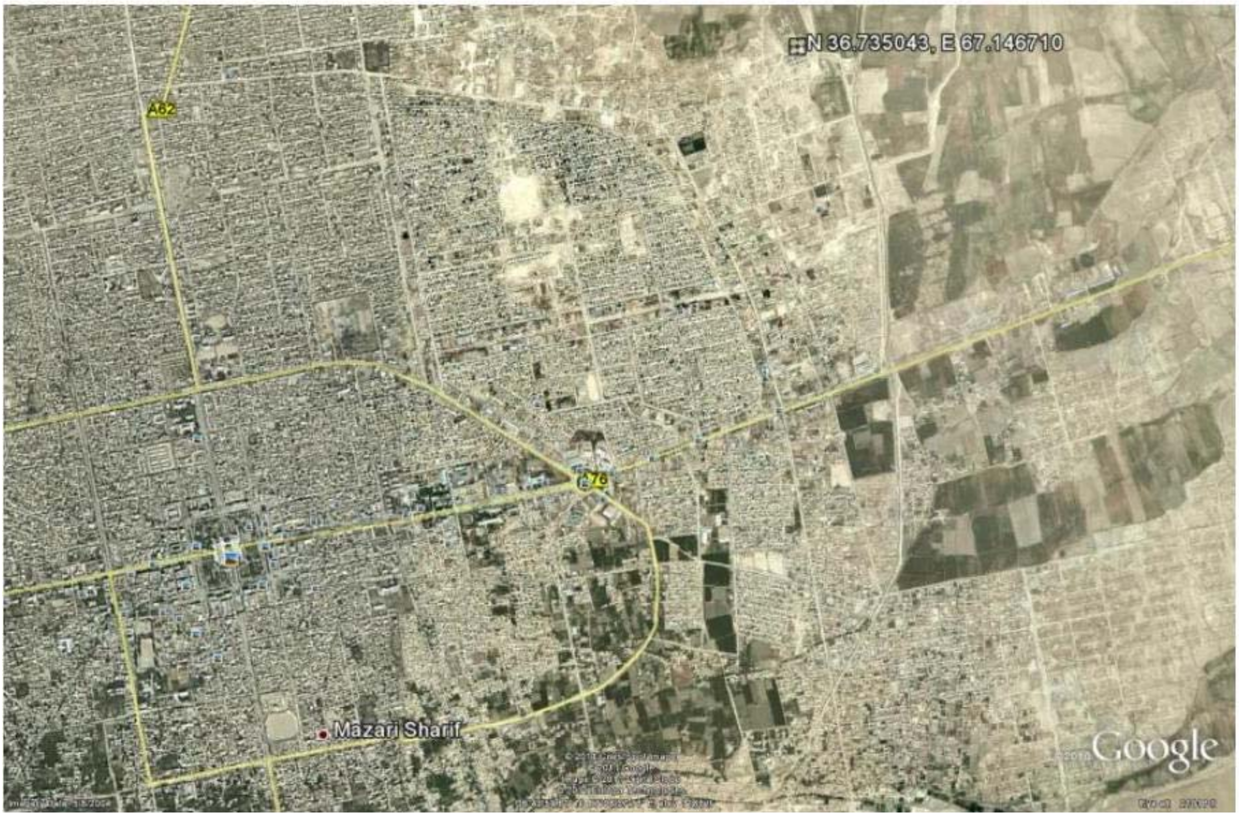

Figure 11 – Aerial view of Mazar e Sharif substation

The substation is a 220kV main and transfer high voltage bus scheme complete with bus coupler. There are two power transformations within the substation; the first transformation is from 220/20kV and used for the local distribution system, the second transformation is from 220/110kV transformation that feeds the existing/old MeZ substation. The new substation appears to be in good working order and condition. There is on-going substation construction for the addition of an additional 50MVA power transformer from 220/20kV.

Notable conditions are the following:

The existing 110kV MeZ substation receives its source through the 220kV system that is step-down through the 50MVA 220/110kV transformer. The 110kV source then runs through a convolution of old switchgear that is in disrepair and eventually to two parallel 16MVA 110/35/6kV transformers. There are two circuits of 35kV sub-transmission system that deliver power to the inner city substation Shadiam and the outlying town of Balkh. All three substations (MeZ, Shadiam, and Balkh) have distribution networks operating at 6kV for localized power delivery.

Mazar-e-Sharif 220kV transmission lines are installed over two 220kV lines identified as Circuit A and Circuit B. Each circuit is single conductor per phase. Circuit A and is energized and receiving electrical energy from Naibabad substation over this circuit at 220kV. However, Circuit B is physically connected to the 220kV bus system inside the substation, and the line disconnects are open.

The single line diagram shows the electrical configuration of the substation, as configured during the substation inspection on July 4th, 2011.

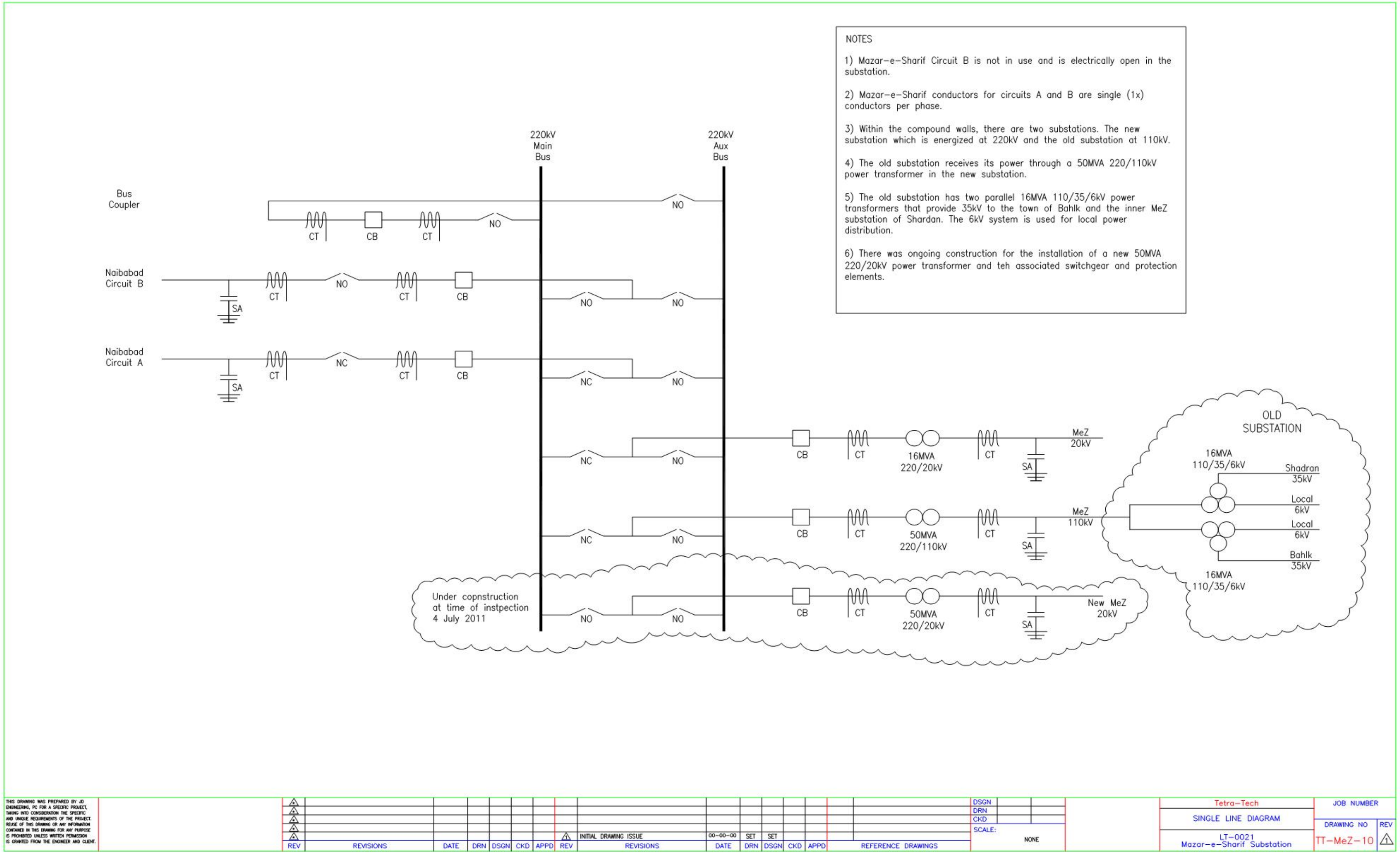

Figure 12 – Single Line Diagram depicting electrical configuration of Mazar-e-Sharif substation

3.3.1 Mazar-e-Sharif Transmission Conductors

The goal of the field investigation to the Mazar-e-Sharif (MeZ) substation was to have the in-service transmission lines de-energized, grounded, and then physically measure the outside diameter of the installed conductor while inspecting the ends of the conductors for the stranding composition. Unfortunately, the transmission system was not able to be de-energized and there was no equipment nor trained personnel available to physically measure the size of the installed conductor. The conductor dead-ends used to terminate the conductor to the towers at the substation entrance at MeZ are identical to the dead-ends used in Pul-e-Khumri & Naibabad. Thus, the conductor stranding of the installed conductor could not be verified.

Fortunately, there was scrap conductor under, or adjacent to, the substation terminal towers for each transmission circuit entering the substation from Naibabad. Each scrap conductor was documented by photographs and the diameter of the scrap conductor physically measured with a micrometer. The substation Manager, [redacted] confirmed the scrap conductor is the same conductor used for each transmission line.

MeZ Scrap Transmission Conductors

Measurement #1	24.99mm
Measurement #2	25.32mm
Measurement #3	25.41mm

Physical counting of the steel and aluminum composition of the conductor was the following:

- 7 Strands Steel
- 26 Strands Aluminum

Figure 13 - MeZ Conductor

Based upon the physical diameter measurement of the conductor and the steel-aluminum stranding composition, the most probable transmission conductor type, from the Naibabad substation, single conductor per phase, two circuit transmission line is code name SQUAB aluminum conductor steel-reinforced, 26 strands aluminum to 7 strands steel, overall diameter 24.51mm, according to the Midal Catalog Conductor Data Sheet (see appendix A).

3.3.2 Mazar-e-Sharif Transformers

The transformer nameplate data collected:

16MVA-220/20kV Transformer
Manufacturer: ABB, 2007
Capacity: 13/16MVA ONAN/ONAF
Frequency and temperature rise: 50Hz and 55°C
Voltages: 220kV/20kV/10kV (HV/LV/TV)
Taps and Impedance: Tap 1 – 10.82%Z, Tap 7 – 10.59%Z, Tap 13 – 10.54%Z
On-Load Tap Changer – 13 position

50MVA-220/110kV Transformer
Manufacturer: ABB, 2007
Capacity: 40/50MVA ONAN/ONAF
Frequency and temperature rise: 50Hz and 55°C
Voltages: 220kV/110kV/20kV (HV/LV/TV)
Taps and Impedance: Tap 1 – 9.86%Z, Tap 7 – 10.10%Z, Tap 13 – 10.49%Z
On-Load Tap Changer – 13 position

New 50MVA-220/20kV Transformer
Manufacturer: Cromton Greaves Ltd. India, 2010
Capacity: 30/50MVA ONAN/ONAF
Frequency and temperature rise: 50Hz and 50°C
Voltages: 220kV/20kV/10kV (HV/LV/TV)
Taps and Impedance: Tap 1 – 11.26%Z, Tap 7 – 10.8%Z, Tap 13 – 10.4%Z

Old 16MVA-110/35/6kV Transformer #1
Manufacturer: Russian, 1983
Capacity: 16/16MVA ONAN/ONAF
Frequency and temperature rise: 50Hz
Voltages: 110kV/35kV/6kV (HV/LV/TV)
Impedance: HV-LV – 10.45%Z, HV-TV – 17.34%Z, LV-TV – 6.34%Z

Old 16MVA-110/35/6kV Transformer #2
Manufacturer: Russian
Capacity: 16/16MVA ONAN/ONAF
Frequency and temperature rise: 50Hz
Voltages: 110kV/35kV/6kV (HV/LV/TV)
Taps and Impedance: HV-LV – 10.56%Z, HV-TV – 17.54%Z, LV-TV – 6.36%Z

3.4 Chimtala Substation (N34.612010, E69.081809)

Figure 14 – Aerial View of Chimtala Substation

The Chimtala substation is a 220kV main and transfer high voltage bus scheme complete with bus coupler. There are two 220kV taps to 160MVA 220/110kV power transformers and a 25MVAR reactor. The substation has existing bus and switchgear installed for five (5) 110kV sources and has installed two (2) 40MVA 110/20kV power transformers feeding multiple distribution feeders. The substation appears to be in good working order and condition.

Notable conditions are the following:

There are two (2) 220kV circuits entering the Chimtala substation. There were no other 220kV circuits entering or leaving the substation at the date of inspection (July 10th, 2011).

The single line diagram depicts the electrical configuration of the substation, as configured during the substation inspection on July 10th, 2011.

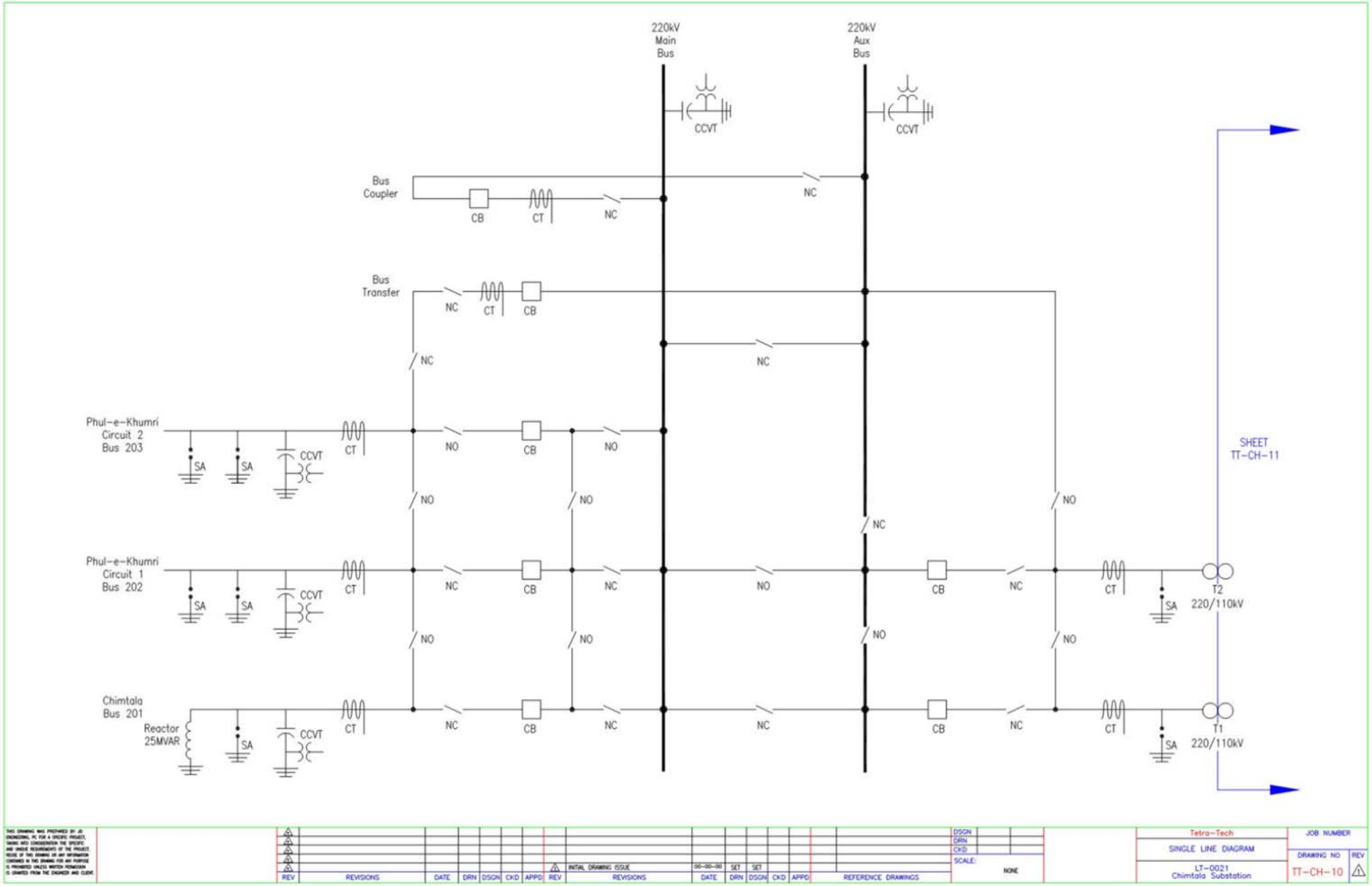

Figure 15 – Chimtala Single Line Electrical Diagrams

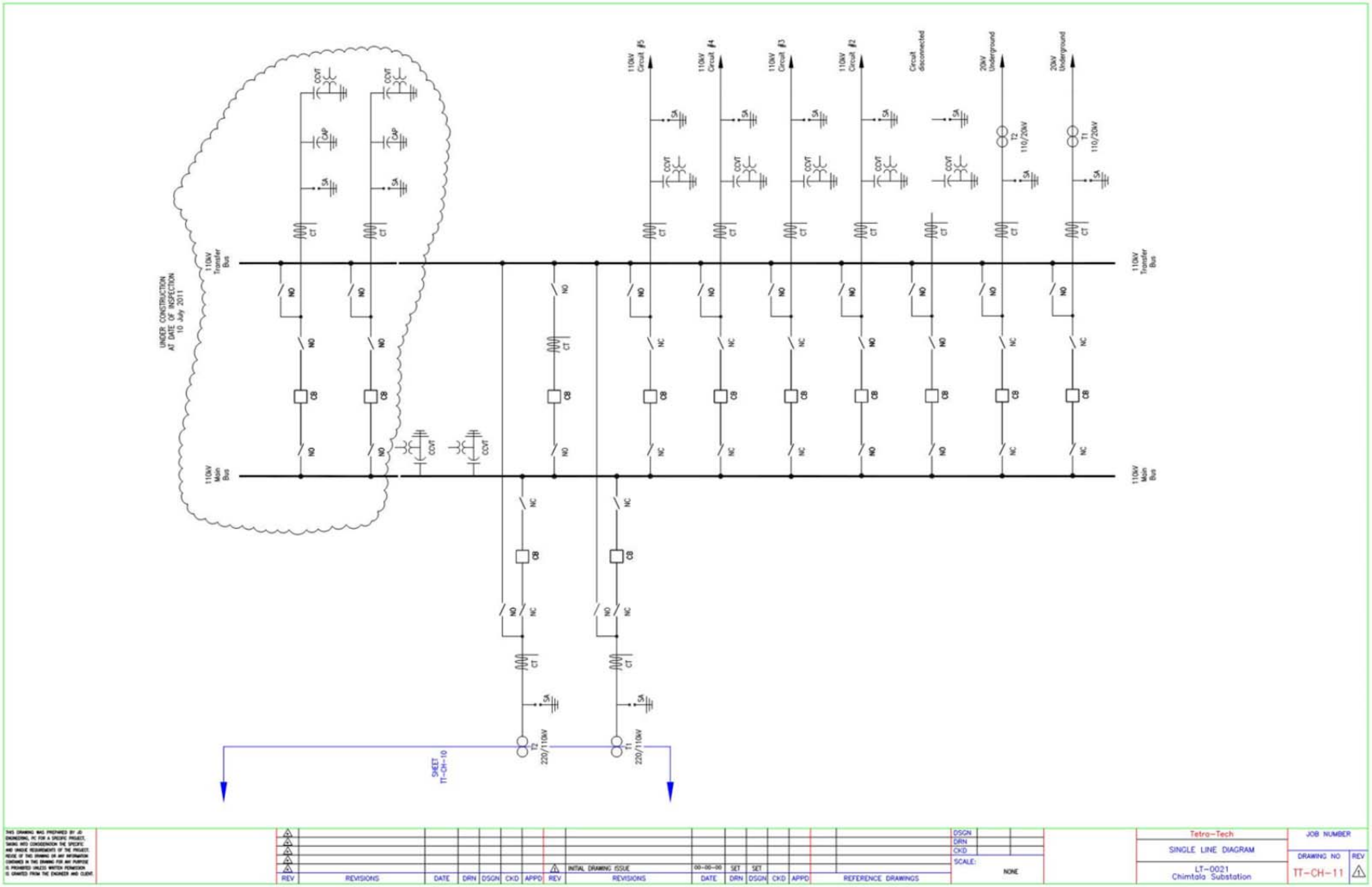

Figure 16 – Chimtala Single Line Electrical Diagram

Chimtala Transmission Conductors
The goal of the field investigation to the Chimtala substation was to have the in-service transmission lines de-energized, grounded, and then physically measure the outside diameter of the installed conductor while inspecting the ends of the conductors for the stranding composition. Unfortunately, the transmission system was not able to be de-energized and there was no equipment nor trained personnel available to physically measure the size of the installed conductor. Furthermore, the conductor dead-ends used to terminate the conductor to the towers at the substation entrance was a closed, compression type fitting. These types of fittings physically cover the conductor ends and the conductor stranding of the installed conductor could not be verified.

Unfortunately, at Chimtala, there were no hand reels of scrap conductor anywhere inside the substation and thus the conductor could not be verified.

3.4.1 Chimtala Transformers

The transformer nameplate data collected:

T#1 – 220/110kV
Manufacturer: Bharat Heavy Electrical Limited, India
Capacity: 160/128/96MVA OFAF/ONAF/ONAN
Frequency and temperature rise: 50Hz and 47°C
Voltages: 220kV/110kV (HV/LV)
Taps and Impedance: 12.5% + 10% tolerance Tap #9

T#2 – 220/110kV
Manufacturer: Bharat Heavy Electrical Limited, India
Capacity: 160/128/96MVA OFAF/ONAF/ONAN
Frequency and temperature rise: 50Hz and 47°C
Voltages: 220kV/110kV (HV/LV)
Taps and Impedance: 12.5% + 10% tolerance Tap #9

Reactor
Manufacturer: Bharat Heavy Electrical Limited, India
Capacity: 25MVAR ONAN

T#1 –110/20kV
Nameplate is missing and not physically attached to transformer. Reasonable assumption can be made that the two transformers could be treated as identical.

T#2 – 110/20kV
Manufacturer: Bharat Heavy Electrical Limited, India
Capacity: 40/24MVA OFAF/ONAN
Frequency and temperature rise: 50Hz and 47°C
Voltages: 110kV/20kV (HV/LV)
Taps and Impedance: 14.16% + 10% tolerance Tap #10

3.5 Sheberghan Substation (N36.554632, E65.714817)

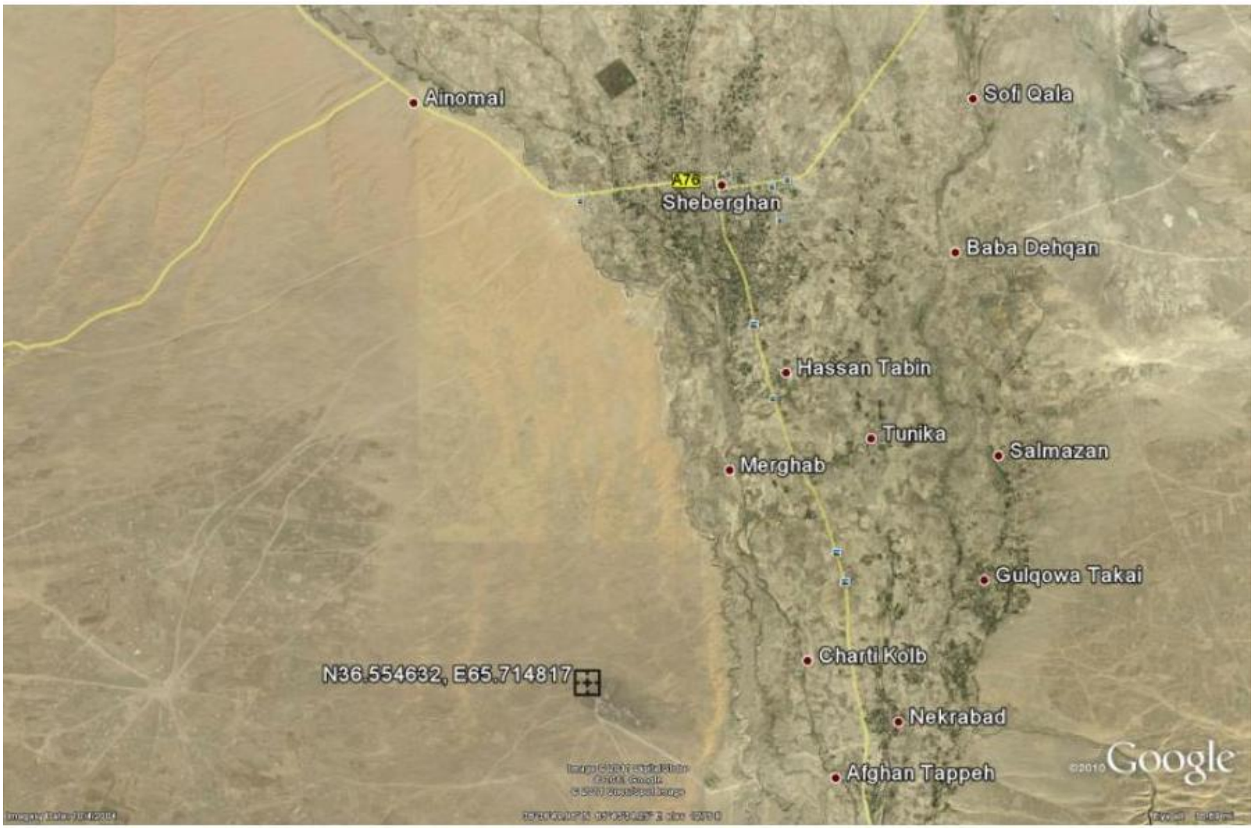

Figure 17 – Aerial View Sheberghan Substation

The Sheberghan substation is a 110kV substation. The inspection of the Sheberghan substation could not be performed during the field visit to the area due to security reasons.

3.5.1 Sheberghan Transmission System

The goal of the field investigation for the Sheberghan Transmission System was to inspect the routing of the transmission poles and lines between Mazar-e-Sharif and Sheberghan substation. It was known prior to the start of the field investigation that the transmission line was no longer in service and in disrepair. Furthermore, the investigation team understood the line had been vandalized and items removed from the towers to include the conductor. Additionally, the team had received information that the transmission system was built on lattice structures.

The field investigation started within the Mazar-e-Sharif substation, where there were 110kV towers used in the old portion of the substation that were still in use to route the 110kV transmission from the new station into the adjacent old substation. All the towers are in good structural condition and the foundations appear to be sound.

The transmission route, supporting structures, insulators, and conductor are no longer in use to support 110kV transmission; however, they are in use to support a 6kV distribution into the North end of Mazar-e-Sharif. The usable distribution extends into the city approximately 6kM and then terminates to a dead-end structure. The remainder of the old transmission line continues to Sheberghan.

The investigation was not able to inspect the entire length of the transmission line between Mazar and Sheberghan; however, was able to inspect approximately 27km of the line. In the section inspected, the route consists of single concrete poles with metal hardware supporting bell-type suspension insulators. The majority of the mono-pole structures are in good and serviceable condition and the three pole dead-end structures are also in good and serviceable condition.

The first 8km of the transmission route (Figure 18) begins at the Mazar-e-Sharif substation in the northeast portion of the town of Mazar-e-Sharif. The transmission line proceeds westerly along the northern boundary of town, but travels through residential areas, homes, and within residential perimeter walls. There were on a number of occasions areas where clearance and right-of-way issues would create difficulties in repairing and rebuilding the transmission line using the existing route.

The next section of transmission route (Figure 19) inspected approximately 19km transverse open farmlands and accessible right-of-ways that would be conducive to the reconstruction of the transmission line. This section of route would be ideal for transmission line construction.

The remaining transmission route was not inspected due to security concerns (Figure 20). From GPS location #37, there was clear right of way for as far as the team could see to the west on the day of inspection (July 6th,2011). The visibility to the west was approximately 10km.

Figure 18 - Mazar to Sheberghan Transmission Route (9kM)

Figure 19 - Mazar to Sheberghan Transmission Route (20kM)

Figure 20 - Mazar to Sheberghan Transmission Route (113kM)

3.5.2 Evaluation of the Sheberghan Transmission System

The Mazar-e-Sharif to Sheberghan transmission system was inspected for approximately 25km from the Mazar substation towards the Sheberghan substation. The transmission line is constructed from concrete mono-pole structures for tangent structures (Figure 21). Angle and dead-end structures are three mono-pole structures that have each individual phase attached to each structure (Figure 22).

Steel brackets that attach to the pole and provide the structural support for the insulators are used in all inspected structures. Porcelain suspension bells are used to support and insulate the conductor (Figure 23).

Figure 21 - Typical Mono Pole Structure

Figure 22 - Typical Three-Pole Dead-end Structure

Figure 23 - Typical Structural Assemblies

The first section of the Mazar-Sheberghan transmission route from the substation until GPS location #34 travels through the northern section of Mazar-e-Sharif (Figure 18) and has multiple clearance and access issues. However, using the existing route, with possible minor modifications, would prove to be the most beneficial since new right-of-way acquisition and easements would not be required.

Unfortunately, the pole height used in the original construction is estimated to be a 15.25m (50ft) pole (see Figure 24). The type of construction used for the 110kV and pole height will not meet National Electrical Safety Code for most obstructions built under the transmission line in residential areas.

The next two sections of transmission route (Figure 19 & Figure 20) traverses agricultural lands and clearance and right-or-way access would not be a major concern. These sections of line could be easily accessed and reconstructed.

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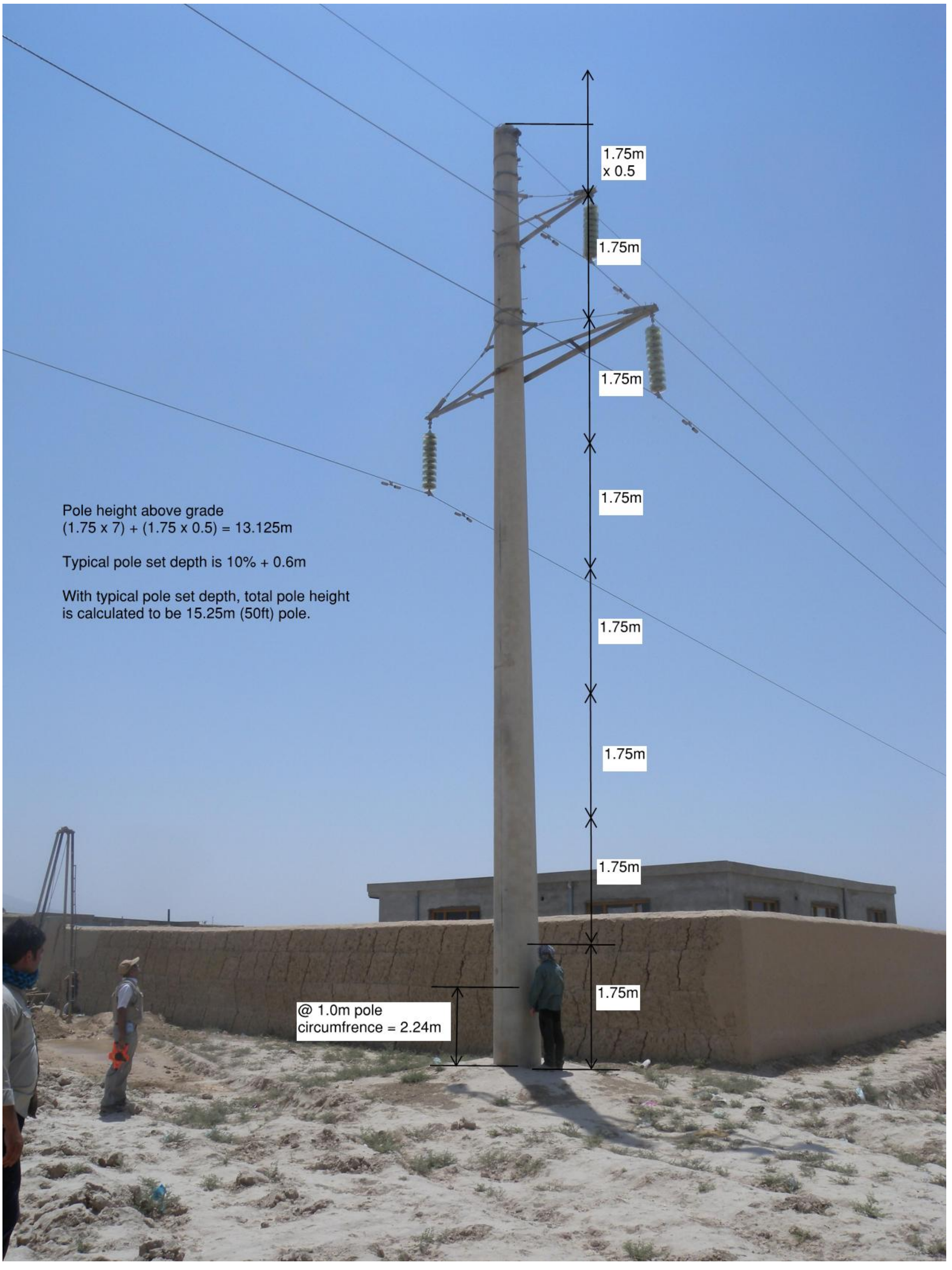

Figure 24 - Typical Structure Height and Clearance

3.6 Thermal Power Plant Interconnection (N36.63818 E66.95239)

Figure 25 – Aerial View Thermal Power Plant Interconnection

The objective for the inspection of the Kud-Bergh substation and 35kV transmission system was to develop and assess the power requirements of the system and interconnection of the surplus generation into the NEPS System.

The Kud-Bergh thermal power plant has a nameplate capacity of 48MW generation capacity across four steam driven generators. The output voltage from the generators is 6.3kV at 50Hz. The generator output terminals connect to the thermal power plant step-up substation located within the facility grounds of the plant. The step-up substation consists of two parallel power transformers each of a rated capacity of 10MVA and a step-up voltage characterization of 6.3/35kV. The 6.3kV sides of the transformers are connected in delta to the output of the generators and the 35kV is connected in Wye.

Unfortunately, the impedance of the step-up transformers do not match. The first transformer (T#1) has a nameplate impedance value of 13.6% and transformer #2 (T2) has an impedance value of 7.93%. The mismatch in impedance values of the two paralleled transformers decreases the available connected output capacity of the substation. The transformer bank has a maximum capacity of 20MVA if the impedances matched, but since there is a mismatch of impedances, the total bank must be de-rated by 0.79. Therefore, the paralleled capacity of the transformer back is not 20MVA but de-rated to 15.8MVA. This is the maximum amount of power that can be delivered into the NEPS system from the Thermal Power plant. The limiting factor is the step-up transformer located within the Thermal Power Plant facility.

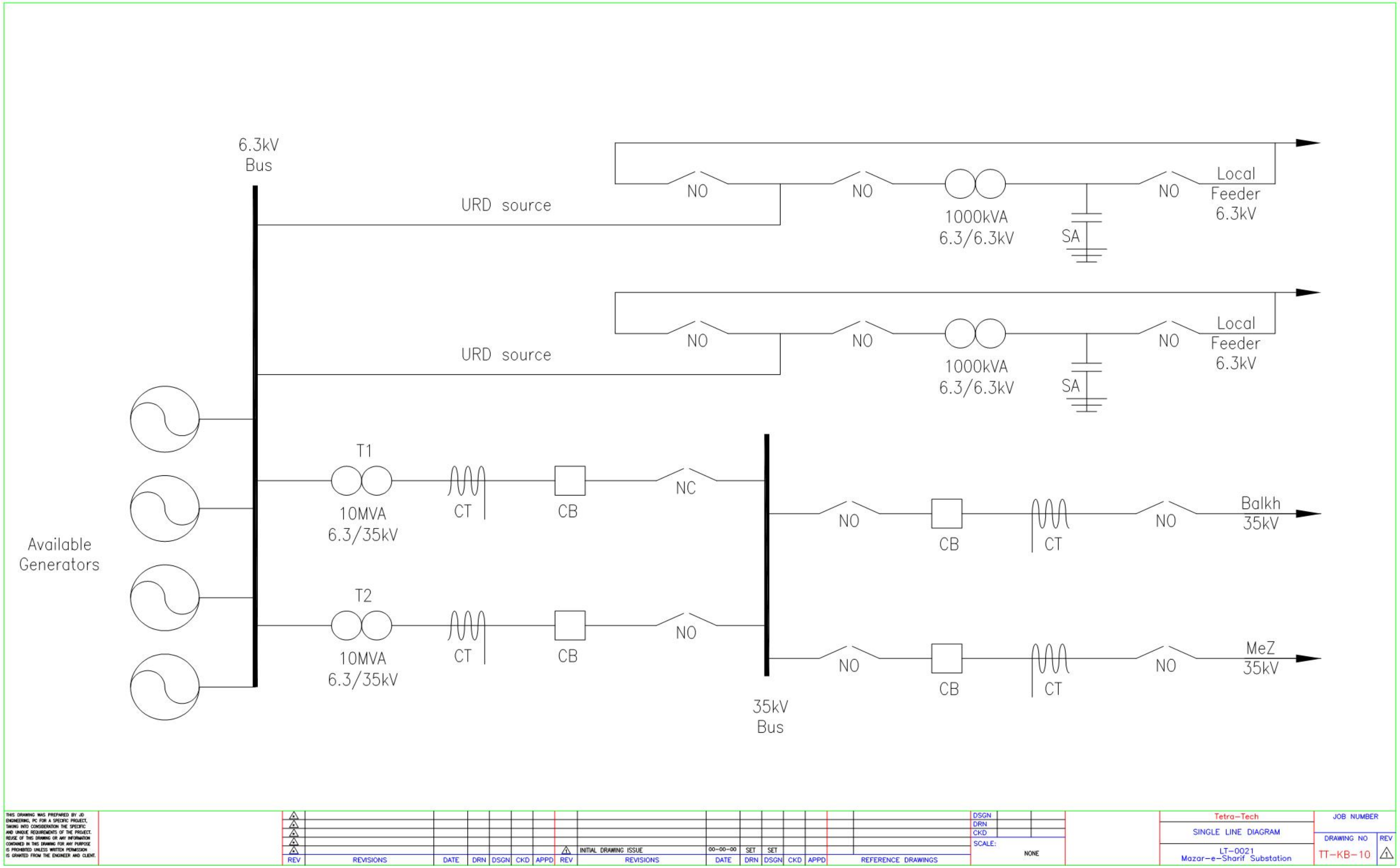

Figure 26 - Single Line Diagram Mazar-e-Sharif Substation

3.6.1 Kud-Bergh Transmission System

There are two 35kV transmission lines that exit the Thermal Power Plant substation. One 35kV line interconnects to the Mazar-e-Sharif substation and the second 35kV line provides electrical energy to the town of Balkh. The Mazar and Balkh lines are both constructed using lattice towers of the same configuration, foundation footprint, and strength. Both lines are in serviceable condition and currently energized at 35kV and in use.

Mazar-e-Sharif Line Section
The route for the Mazar line section is along the southern portion of the city and then turns North just before the airport (see Figure 27). The transmission line is approximately 26km and route is open and crosses agricultural land for approximately 15km and then enters congested residential areas. There are some clearance concerns where the transmission line travels through the southern area of town, but generally the line is clear of obstructions. If the line was to be reconstructed or the right of way used for a larger circuit, the agricultural area would pose little difficulty for reconstruction, but the portion of line through the residential areas would be difficult.

At tower number 4 (see Figure 27), the 35kV line is jumpered across the phases. The 35kV line from MeZ to the Kud-Bergh substation jumper is open, and the MeZ line is directly connected to the Balkh 35kV line. The Balkh 35kV line provides the source to Balkh and also the Kud-Bergh plant.

Balkh Line Section
The 35kV line section from Kud-Bergh thermal power plant to the town of Balkh is identical steel lattice type construction and is approximately 14km in length (see Figure 28). The actual length of the transmission line is estimated as the investigation did not extend to the Balkh substation.

The insulators are bell type suspension insulators and the line is energized at 35kV (see Figure 29). The portions of the line inspected appear to be in serviceable condition with no clearance issues noted. The complete line section was not inspected, but the line was inspected up to the intersection of the Sheberghan 110kV transmission line.

Recommendation

The most feasible engineering solution, based upon the maximum power output of available generation of 15.8MVA (see introduction of Section 3.6) would be to use the existing 35kV system in place and interconnect to a new 35/110kV substation and switchyard at the intersection location of the Balkh 35kV and Sheberghan 110kV transmission lines (see Figure 30). The coordinates for this intersection is (N36.67622 E66.91479).

The installation of a new substation at this location would provide a short interconnection location for the surplus generation into the 110kV NEPS system, provide a strong source to the town of Balkh, and provide an additional source to the Shadiam Substation (35kV) in the southern portion of Mazar-e-Sharif (see Figure 27). The existing conductors and structures would be sufficient to carry the additional generation at the calculated surplus capacity.

Figure 27 - Kud-Bergh to Mazar-e-Sharif 35kV Transmission Line

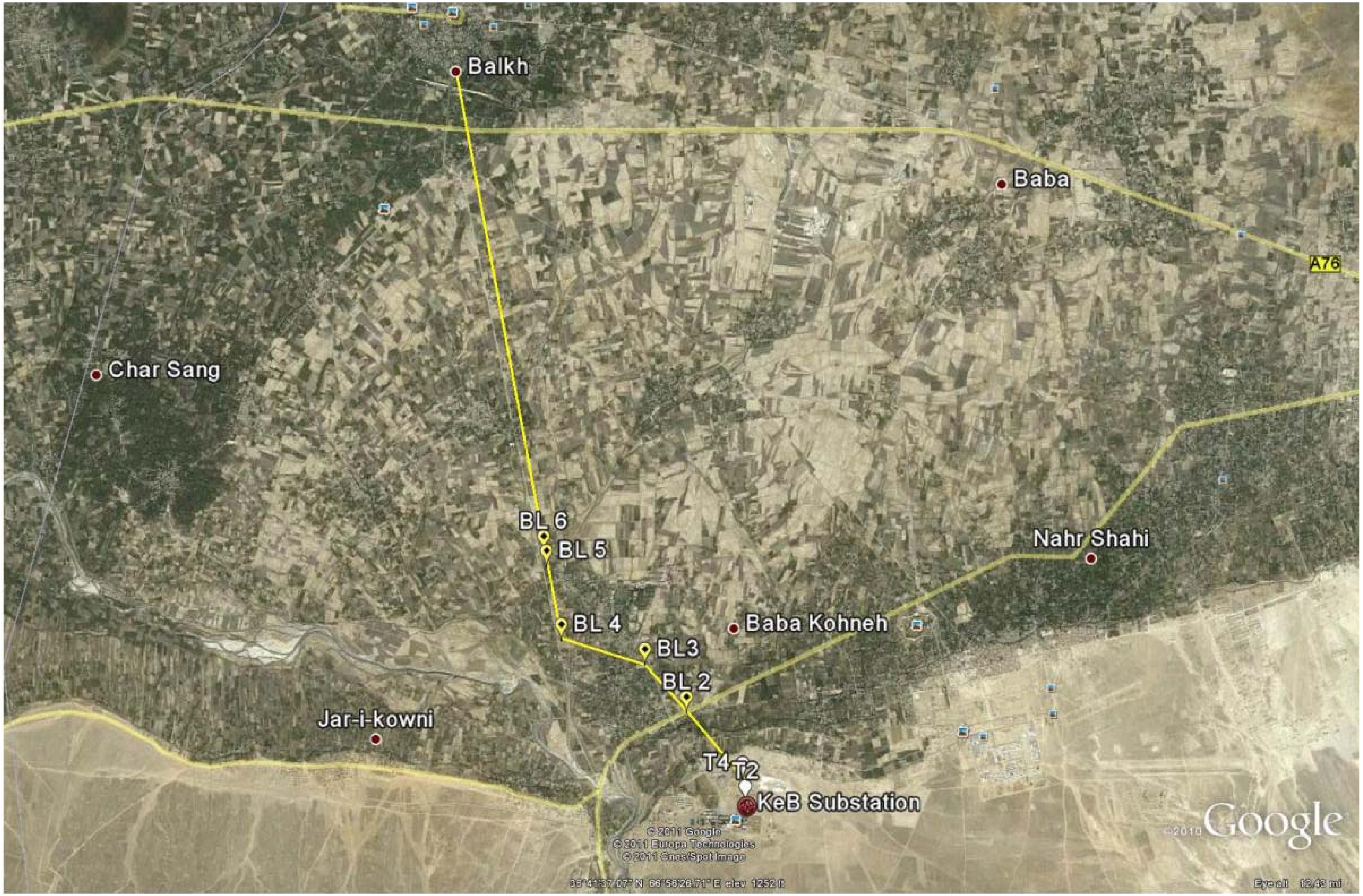

Figure 28 - Kud-Bergh to Balkh 35kV Transmission Line

Figure 29 - Typical Kud-Bergh 35kV Transmission Line Tangent Structure

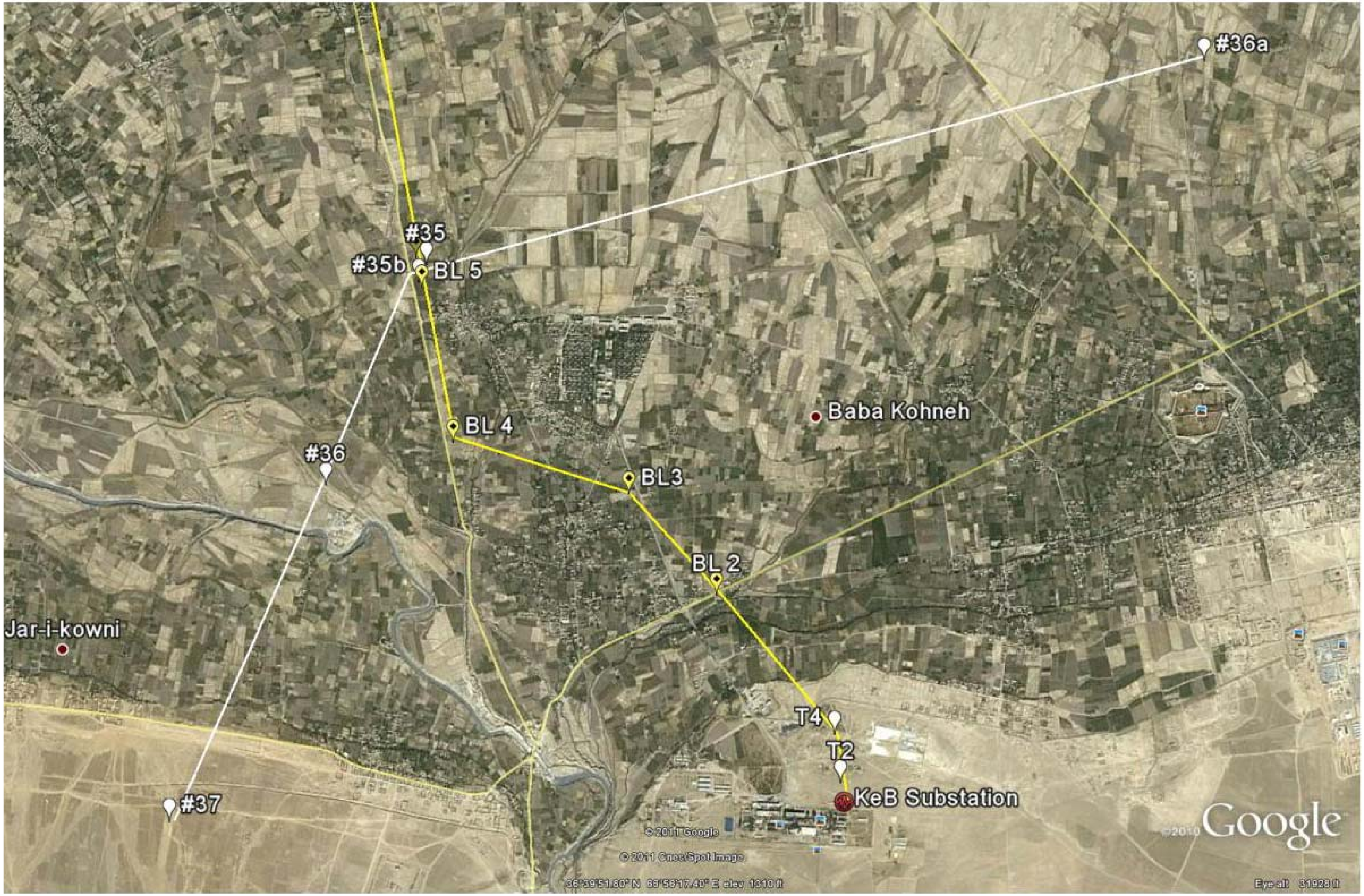

Figure 30 - Kud-Bergh to Balkh 35kV & Sheberghan Intersecting Transmission Lines

3.7 AMU River Crossing (N37.22758, E67.44004)

Figure 31 – AMU River Crossing

The objective for the inspection of the AMU River Crossing was to develop alternatives for an additional high voltage river crossing. Two approaches were investigated. The first approach is to design a new aerial crossing east of the existing river crossing. The second option is to install underground cable from a new tower location on the Afghanistan side of the river west to the rail bridge (Friendship Bridge), attach conduits to the bridge and then east from the Uzbekistan side of the river crossing to the substation.

The existing crossing is a double circuit 220kV transmission system that connects into the Naibabad substation. The Uzbekistan tower (Figure 32) appears to be the same type and style as the Afghanistan structure (Figure 33). The dead-end structure (Figure 34) is assumed to be of the same style as on the Uzbekistan side of the river crossing.

Recommendation

The structures and foundations appear to be in serviceable condition and there does not appear to be any major structural issue with the Afghanistan tower or dead-end structure. However, the transmission conductor jumper across the dead-end is not a suitable connector for the transmission system (Figure 35). It is highly recommended that all the transmission conductor connectors across this dead-end be changed out to properly rated compression type connectors rated for the maximum current flow across the transmission line.

Figure 32 - AMU River Crossing (Uzbekistan side)

Figure 33 - AMU River Crossing Structure (Afghanistan side)

Figure 34 - AMU River Crossing Dead-end Structure (Afghanistan side)

Figure 35 - AMU River Crossing Conductor Connector

3.7.1 AMU River Crossing Options

A. The additional aerial overhead crossing consists of new towers and dead-end structures on each side of the river crossing. There would also be requirements to interconnect into the existing Uzbekistan substation.

B. Underground crossing of the AMU River using a conduit system attached to the existing railway bridge.

   This option for crossing the AMU River, consists of installing a single dead-end tower on the Afghanistan side for the take-off of a new transmission system to Mazar-e-Sharif, but no structures further than this initial dead-end start point of the new transmission line. Additionally, there would also be requirements to interconnect into the existing Uzbekistan substation. The report does not include the development of interconnection into the substation nor the reconstruction of a transmission line to Mazar-e-Sharif.

4.0 Conclusions

The 220kV transmission system and associated substation are in excellent condition. The investment into the electrical infrastructure is demonstrated through the excellent conditions of the electrical system inspected.

The goal of the field investigations of the NEPS 220kV system and substations was to have the in-service transmission lines de-energized, grounded, and then physically measure the outside diameter of the installed conductor while inspecting the ends of the conductors for the stranding composition. Unfortunately, the transmission system was not able to be de-energized and there was no equipment nor trained personnel available to physically measure the size of the installed conductor. Furthermore, the conductor dead-ends used to terminate the conductor to the towers at the substation entrance was a closed, compression type fitting.

The conductor diameters do not directly correspond to the values provided for the diameters of cables listed in the Midal catalog data sheets. However, due to the inconstancies in the measurements, a reasonable assumption has to be postulated. It is plausible that measurements taken would be greater in diameter than the actual conductor diameters listed in the Midal catalog data sheets and only on rare instances would the diameter of the cable be less than stated values. This is the case for the measurements taken in the field.

Although the actual installed conductor could not be verified, the inspection, verification, and recording of the scrap conductor size near and adjacent to the installed transmission dead-ends in the substation provides better information of the installed conductor size. At a minimum, it increases the confidence of the size and type of conductors that were installed on the transmission lines.

The investigation of the Sheberghan 110kV transmission system found that it is not in service, nor in good condition, but the concrete mono-pole structures are in place. The conductor is broken and down in practically every span, and the hardware is in poor condition. However, a portion of the transmission structures and insulators are currently in use to provide distribution voltage to a portion of the northern section of Mazar-e-Sharif.

The mono-pole structures appear to be in good condition and could be used to reconstruct the transmission line provided the conductor tension and design loading factors do not exceed the safety margins of the calculated pole strength. If 200MW are to be carried over this transmission route at 110kV, the pole lines are grossly inadequate for strength requirements due to the required conductors size and the poles would be too short to provide adequate clearance (Figure 24).

The Kud-Bergh thermal power plant substation and associated transmission system was investigated for incorporation of surplus generation incorporated into the NEPS system. The recommendation of a new substation constructed into the existing crossing of the Sheberghan 110kV system and the 35kV system to the town of Balkh is recommended.

Unfortunately, the impedance of the step-up transformers do not match. The first transformer (T#1) has a nameplate impedance value of 13.6% and transformer #2 (T2) has an impedance value of 7.93%. The mismatch in impedance values of the two paralleled transformers decreases the available connected output capacity of the substation. The transformer bank has a maximum capacity of 20MVA if the impedances matched, but since there is a mismatch of impedances, the total bank must be de-rated by 0.79. Therefore, the paralleled capacity of the transformer back is not 20MVA but de-rated to 15.8MVA. This is the maximum amount of power that can be delivered into the NEPS system from the Thermal Power plant. The limiting factor is the step-up transformer located within the Thermal Power Plant facility.

The most feasible engineering solution, based upon the maximum power output of available generation of 15.8MVA (see introduction of Section 3.6) would be to use the existing 35kV system in place and interconnect to a new 35/110kV substation and switchyard at the intersection location of the Balkh 35kV and Sheberghan 110kV transmission lines (see Figure 28). The coordinates for this intersection is (N36.67622 E66.91479).

The installation of a new substation at this location would provide a short interconnection location for the surplus generation into the 110kV NEPS system, provide a strong source to the town of Balkh, and provide an additional source to the Shadiam Substation (35kV) in the southern portion of Mazar-e-Sharif (see Figure 25). The existing conductors and structures would be sufficient to carry the additional generation at the calculated surplus capacity.

An additional AMU river crossing is possible. At the date of inspection, July 3rd, 2011, there was adequate room east of the existing crossing to install an additional aerial river crossing. Unfortunately, it was not possible to travel into Uzbekistan to physically inspect the substation and route for an additional circuit into the existing substation.

The structures and foundations appear to be in serviceable condition and there does not appear to be any major structural issue with the Afghanistan tower or dead-end structure. However, the transmission conductor jumper across the dead-end is not a suitable connector for the transmission system (Figure 35). It is highly recommended that all the transmission conductor connectors across this dead-end be changed out to properly rated compression type connectors rated for the maximum current flow across the transmission line.

APPENDICES

Appendix A Midal Cable References

CONDUCTOR DATA SHEET

ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)

ASTM SIZES

Code Name	Area				Equivalent copper area		Stranding and wire diameter		Approx. overall diameter	Weight			Rated Strength	Maximum dc resistance at 20 °C
	Aluminium		Steel	Total			Aluminium	Steel		Aluminium	Steel	Total		
	AWG or MCM	mm^2	mm^2	mm^2	AWG or MCM	mm^2	mm	mm	mm	kg/km	kg/km	kg/km	kN	Ω /km
TURKEY	6	13.30	2.22	15.52	8	8.39	6/1.68	1/1.68	5.04	36.5	17	54	5.28	2.1499
THRUSH	5	16.83	2.81	19.64	7	10.58	6/1.89	1/1.89	5.67	46.0	22	68	6.68	1.6987
SWAN	4	21.18	3.53	24.71	6	13.29	6/2.12	1/2.12	6.36	58.0	27	85	8.30	1.3501
SWANATE	4	21.12	5.35	26.47	6	13.29	7/1.96	1/2.61	6.53	58.0	42	100	10.68	1.3539
SWALLOW	3	26.69	4.45	31.14	5	16.77	6/2.38	1/2.38	7.14	73.0	35	108	10.21	1.0712
SPARROW	2	33.59	5.60	39.19	4	21.16	6/2.67	1/2.67	8.01	92.0	44	136	12.69	0.8512
SPARATE	2	33.54	8.55	42.09	4	21.16	7/2.47	1/3.30	8.24	92.0	67	159	16.14	0.8525
ROBIN	1	42.41	7.07	49.48	3	26.65	6/3.00	1/3.00	9.00	116.0	55	171	15.81	0.6742
RAVEN	1/0	53.52	8.92	62.44	2	33.61	6/3.37	1/3.37	10.11	147.0	69	216	19.35	0.5343
QUAIL	2/0	67.33	11.22	78.55	1	42.39	6/3.78	1/3.78	11.34	185.0	87	272	23.27	0.4247
PIGEON	3/0	85.12	14.19	99.31	1/0	53.48	6/4.25	1/4.25	12.75	234.0	110	344	29.42	0.3359
PENGUIN	4/0	107.20	17.87	125.10	2/0	67.42	6/4.77	1/4.77	14.31	294.0	139	433	36.54	0.2667
WAXWING	266.8	135.00	7.50	142.50	3/0	85.03	18/3.09	1/3.09	15.45	372.0	59	431	30.27	0.2118
OWL	266.8	135.40	17.62	153.00	3/0	85.03	6/5.36	7/1.79	16.09	371.0	138	512	42.95	0.2112
PARTRIDGE	266.8	134.90	21.99	156.90	3/0	85.03	26/2.57	7/2.00	16.28	373.0	172	545	50.23	0.2141
OSTRICH	300	152.20	24.71	176.90	189	95.48	26/2.73	7/2.12	17.28	422.0	193	615	56.55	0.1897
MERLIN	336.4	170.20	9.46	179.70	4/0	107.23	18/3.47	1/3.47	17.35	469.0	74	543	38.17	0.1688
LINNET	336.4	170.60	27.83	198.40	4/0	107.23	26/2.89	7/2.25	18.31	473.0	217	690	62.76	0.1693
ORIOLE	336.4	170.50	39.78	210.30	4/0	107.23	30/2.69	7/2.69	18.83	474.0	311	785	77.43	0.1698
CHICKADEE	397.7	200.90	11.16	212.10	250	126.45	18/3.77	1/3.77	18.85	555.0	87	642	43.37	0.1430
BRANT	397.5	201.60	26.13	227.70	250	126.45	24/3.27	7/2.18	19.62	558.0	204	762	64.72	0.1433
IBIS	397.5	201.30	32.73	234.00	250	126.45	26/3.14	7/2.44	19.88	558.0	256	814	72.05	0.1434
LARK	397.5	200.90	46.88	247.80	250	126.45	30/2.92	7/2.92	20.44	558.0	367	925	90.30	0.1441

Note: All the data set out in this catalogue is given for information purpose only and Midal Cables shall not be held responsible for its accuracy

CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)

ASTM SIZES

Code Name	Area				Equivalent copper area		Stranding and wire diameter		Approx. overall diameter	Weight			Rated Strength	Maximum dc resistance at 20 °C
	Aluminium		Steel	Total			Aluminium	Steel		Aluminium	Steel	Total		
	AWG or MCM	mm²	mm²	mm²	AWG or MCM	mm²	mm	mm	mm	kg/km	kg/km	kg/km	kN	Ω /km
PELICAN	477	242.30	13.46	255.80	300	152.26	18/4.14	1/4.14	20.70	668.0	105	773	52.30	0.1186
FLICKER	477	241.60	31.40	273.00	300	152.26	24/3.58	7/2.39	21.49	669.0	245	914	76.78	0.1195
HAWK	477	241.60	39.49	281.10	300	152.26	26/3.44	7/2.68	21.80	669.0	306	975	86.73	0.1195
HEN	477	241.30	56.30	297.60	300	152.26	30/3.20	7/3.20	22.40	670.0	440	1110	105.16	0.1200
OSPREY	556.5	282.50	15.69	298.20	350	172	18/4.47	1/4.47	22.35	779.0	122	901	60.52	0.1017
PARAKEET	556.5	282.30	36.60	318.90	350	172	24/3.87	7/2.58	23.22	783.0	286	1069	88.29	0.1023
DOVE	556.5	282.60	45.92	328.50	350	172	26/3.72	7/2.89	23.55	783.0	359	1142	101.10	0.1022
EAGLE	556.5	282.10	65.82	347.90	350	172	30/3.46	7/3.46	24.21	784.0	515	1298	122.90	0.1026
PEACOCK	605	306.10	39.78	345.90	381	187	24/4.03	7/2.69	24.20	849.0	311	1160	95.86	0.0943
SQUAB	605	305.80	49.81	355.60	381	187	26/3.87	7/3.01	24.51	848.0	389	1237	109.60	0.0944
WOODDUCK	605	307.10	71.65	378.80	381	187	30/3.61	7/3.61	25.25	853.0	560	1413	129.00	0.0943
TEAL	605	307.10	69.62	376.70	381	187	30/3.61	19/2.16	25.24	853.0	545	1398	136.10	0.0943
KINGBIRD	636	323.00	17.95	341.00	400	197	18/4.78	1/4.78	23.90	891.0	140	1031	69.72	0.0890
ROOK	636	323.10	41.88	365.00	400	197	24/4.14	7/2.76	24.84	896.0	327	1223	101.00	0.0894
GROSBEAK	636	321.80	52.49	374.30	400	197	26/3.97	7/3.09	25.15	892.0	410	1302	111.90	0.0897
SCOTER	636	322.60	75.26	397.90	400	197	30/3.70	7/3.70	25.90	897.0	588	1485	135.50	0.0897
EGRET	636	322.60	73.54	396.10	400	197	30/3.70	19/2.22	25.90	897.0	576	1473	140.60	0.0897
FLAMINGO	666.6	337.30	43.72	381.00	419	206	24/4.23	7/2.82	25.34	935.0	342	1277	105.50	0.0856
GANNET	666.6	338.30	54.90	393.20	419	201	26/4.07	7/3.16	25.76	938.0	429	1367	117.30	0.0854
CROW	715.5	361.60	46.88	408.50	450	221	54/2.92	7/2.92	26.28	1003.0	366	1369	115.20	0.0799
STILT	715.5	363.30	46.88	410.20	450	222	24/4.39	7/2.92	26.32	1007.0	366	1373	113.30	0.0795
STARLING	715.5	361.90	59.15	421.10	450	221	26/4.21	7/3.28	26.68	1004.0	462	1466	125.90	0.0798
REDWING	715.5	362.10	82.41	444.50	450	221	30/3.92	19/2.35	27.43	1006.0	645	1651	153.70	0.0800

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	Aluminium		Steel	Total			Aluminium	Steel		Aluminium	Steel	Total		
	AWG or MCM	mm^2	mm^2	mm^2	AWG or MCM	mm^2	mm	mm	mm	kg/km	kg/km	kg/km	kN	Ω /km
TERN	795	403.80	27.83	431.60	500	246	45/3.38	7/2.25	27.03	1120.0	217	1337	97.47	0.0715
CONDOR	795	402.30	52.15	454.50	500	245	54/3.08	7/3.08	27.72	1116.0	407	1523	124.30	0.0718
CUCKOO	795	402.30	52.15	454.50	500	245	24/4.62	7/3.08	27.72	1116.0	407	1523	123.80	0.0718
DRAKE	795	402.60	65.44	468.00	500	246	26/4.44	7/3.45	28.11	1116.0	511	1627	139.70	0.0717
MALLARD	795	403.80	91.78	495.60	500	246	30/4.14	19/2.48	28.96	1122.0	718	1840	171.20	0.0717
CRANE	874.5	442.50	57.36	499.90	550	270	54/3.23	7/3.23	29.07	1221.0	448	1669	136.70	0.0649
RUDDY	900	455.50	31.67	487.20	566	278	45/3.59	7/2.40	28.74	1268.0	247	1510	109.40	0.0634
CANARY	900	456.30	59.15	515.50	566	278	54/3.28	7/3.28	29.52	1265.0	462	1727	141.00	0.0633
RAIL	954	483.80	33.54	517.30	600	295	45/3.70	7/2.47	29.61	1342.0	262	1604	116.10	0.0597
CARDINAL	954	484.50	62.81	547.30	600	296	54/3.38	7/3.38	30.42	1343.0	491	1834	149.70	0.0596
ORLAN	1033.5	523.90	36.31	560.20	650	320	45/3.85	7/2.57	30.81	1453.0	283	1736	123.30	0.0551
CURLEW	1033.5	525.50	68.10	593.60	650	321	54/3.52	7/3.52	31.68	1457.0	532	1989	162.40	0.0550
BLUEJAY	1113	565.50	38.90	604.40	700	345	45/4.00	7/2.66	31.98	1568.0	304	1872	132.70	0.0511
FINCH	1113	565.00	71.57	636.60	700	345	54/3.65	19/2.19	32.85	1574.0	560	2134	174.60	0.0514
BUNTING	1192.5	605.80	41.90	647.70	750	370	45/4.14	7/2.76	33.12	1680.0	327	2007	142.40	0.0477
GRACKLE	1192.5	602.80	76.90	679.70	750	368	54/3.77	19/2.27	33.97	1680.0	601	2281	184.20	0.0481
BITTERN	1272	644.40	44.70	689.10	800	393	45/4.27	7/2.85	34.17	1787.0	349	2136	151.40	0.0448
PHEASANT	1272	645.10	81.71	726.80	800	394	54/3.90	19/2.34	35.10	1797.0	640	2137	194.10	0.0450
DIPPER	1351.5	684.20	47.20	731.10	850	417	45/4.40	7/2.92	35.16	1897.0	366	2263	160.30	0.0422
MARTIN	1351.5	685.40	86.70	772.10	850	418	54/4.02	19/2.41	36.17	1910.0	678	2588	206.10	0.0423
BOBOLINK	1431	725.20	50.10	775.40	900	442	45/4.53	7/3.02	36.24	2011.0	392	2403	168.60	0.0398
PLOVER	1431	726.90	91.80	818.70	900	443	54/4.14	19/2.48	37.24	2025.0	719	2744	218.40	0.0399
NUTHATCH	1510.5	764.20	52.80	817.00	950	466	45/4.65	7/3.10	37.20	2119.0	413	2532	177.60	0.0378
PARROT	1510.5	766.10	97.00	863.10	950	467	54/4.25	19/2.55	38.25	2134.0	760	2894	230.50	0.0379

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CONDUCTOR DATA SHEET

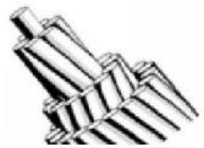
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)

ASTM SIZES

Code Name	Area				Equivalent copper area		Stranding and wire diameter		Approx. overall diameter	Weight			Rated Strength	Maximum dc resistance at 20 °C
	Aluminium		Steel	Total			Aluminium	Steel		Aluminium	Steel	Total		
	AWG or MCM	mm^2	mm^2	mm^2	AWG or MCM	mm^2	mm	mm	mm	kg/km	kg/km	kg/km	kN	Ω /km
LAPWING	1590	804.10	55.60	859.80	1000	491	45/4.77	7/3.18	38.16	2230.0	424	2664	186.90	0.0359
FALCON	1590	806.20	102.40	908.70	1000	492	54/4.36	19/2.62	39.26	2246.0	802	3048	243.00	0.0360
CHUKER	1780	903.20	73.50	976.70	1119	551	84/3.70	19/2.22	40.70	2516.0	576	3092	227.80	0.0321
High Strength Strandings														
GROUSE	80	40.54	14.12	54.66	50	25	8/2.54	1/4.24	9.32	111.0	110	221	23.06	0.7089
PETREL	101.8	51.61	30.10	81.71	64	32	12/2.34	7/2.34	11.70	143.0	235	378	46.16	0.5595
MIORCA	110.8	56.11	32.73	88.84	70	34	I 2/2.44	7/2.44	12.20	155.0	256	411	50.19	0.5146
LEGHORN	134.6	68.20	39.78	108.00	85	42	12/2.69	7/2.69	13.46	189.0	311	500	60.67	0.4234
GUINEA	159	80.36	46.88	127.20	100	49	12/2.92	7/2.92	14.60	223.0	367	590	71.10	0.3593
DOTTEREL	176.9	89.41	52.15	141.60	111	55	12/3.08	7/3.08	15.40	248.0	408	656	76.68	0.3230
DORKING	190.8	96.5 I	56.30	152.80	120	59	12/3.20	7/3.20	16.00	267.0	440	707	82.77	0.2992
COCHIN	211.3	107.00	62.44	169.40	133	65	12/3.37	7/3.37	16.85	296.0	488	784	91.79	0.2698
BRAHMA	203.2	102.80	91.78	194.60	128	63	16/2.86	19/2.48	18.12	285.0	718	1003	126.52	0.2809

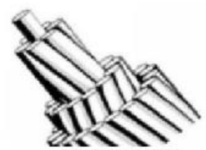
CONDUCTOR DATA SHEET

ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)



BRITISH SIZES

Code Name	Nominal aluminium area	Equivalent copper area	Stranding and wire diameter		Overall diameter	Total area			Weights			Calculated breaking load	Maximum dc resistance at 20 °C
			Aluminium	Steel		Aluminium	Steel	Total	Aluminium	Steel	Total		
	mm^2	mm^2	mm	mm	mm	mm^2	mm^2	mm^2	kg/km	kg/km	kg/km	kN	Ω /km
MOLE	10	6.5	6/1.50	1/1.50	4.5	10.6	1.77	12.4	29	14	43	4.1	2.7060
SQUIRREL	20	12.9	6/2.11	1/2.11	6.33	20.98	3.49	24.5	58	27	85	7.9	1.3700
GOPHER	25	16.1	6/2.36	1/2.36	7.08	26.25	4.37	30.6	72	34	106	9.6	1.0930
WEASEL	30	19.4	6/2.59	1/2.59	7.77	31.61	5.27	36.9	87	41	128	11.4	0.9077
FOX	35	22.6	6/2.79	1/2.79	8.37	36.68	6.11	42.8	101	48	149	13.2	0.7822
FERRET	40	25.8	6/3.00	1/3.00	9	42.41	7.07	49.5	117	55	172	15.2	0.6766
RABBIT	50	32.3	6/3.35	1/3.35	10.05	52.88	8.81	61.7	145	69	214	18.4	0.5426
MINK	60	38.7	6/3.66	1/3.66	10.98	63.13	10.52	73.7	173	82	255	21.9	0.4545
SKUNK	60	38.7	12/2.59	7/2.59	12.95	63.22	36.88	100.1	175	290	465	52.9	0.4568
BEAVER	70	45.2	6/3.99	1/3.99	11.97	75.02	12.50	87.5	205	97	302	25.8	0.3825
HORSE	70	45.2	12/2.79	7/2.79	13.95	73.36	42.80	116.2	203	335	538	61.2	0.3936
RACOON	75	48.4	6/4.10	1/4.10	12.3	79.21	13.20	92.4	217	103	320	27.2	0.3623
OTTER	80	51.6	6/4.22	1/4.22	12.66	83.92	13.99	97.9	230	109	339	28.8	0.3419
CAT	90	58.1	6/4.50	1/4.50	13.5	95.43	15.90	111.3	262	124	386	32.7	0.3006
HARE	100	64.5	6/4.72	1/4.72	14.16	105	17.50	122.5	288	137	425	35.9	0.2733
DOG	100	64.5	6/4.72	7/1.57	14.15	105	13.55	118.6	288	106	394	32.7	0.2733
HYENA	100	64.5	7/4.39	7/1.93	14.57	106	20.48	126.5	290	160	450	41.0	0.2702
LEOPARD	125	80.7	6/5.28	7/1.75	15.81	131.4	16.84	148.5	360	132	492	40.8	0.2185
COYOTE	125	80.7	26/2.54	7/1.91	15.89	131.7	20.06	151.8	365	157	522	46.3	0.2191
COUGAR	125	80.7	18/3.05	1/3.05	15.25	131.5	7.31	138.8	362	57	419	30.1	0.2190



CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)

BRITISH SIZES

Code Name	Nominal aluminium area	Equivalent copper area	Stranding and wire diameter		Overall diameter	Total area			Weights			Calculated breaking load	Maximum dc resistance at 20 °C
			Aluminium	Steel		Aluminium	Steel	Total	Aluminium	Steel	Total		
	mm^2	mm^2	mm	mm	mm	mm^2	mm^2	mm^2	kg/km	kg/km	kg/km	kN	Ω /km
TIGER	125	80.7	30/2.36	7/2.36	16.52	131.2	30.62	161.8	362	240	602	58.0	0.2202
WOLF	150	96.8	30/2.59	7/2.59	18.13	158.1	36.88	194.9	437	289	726	69.2	0.1828
DINGO	150	97.9	18/3.35	1/3.35	16.75	158.7	8.81	167.5	437	69	506	35.7	0.1815
LYNX	175	113	30/2.79	7/2.79	19.53	183.4	42.79	226.2	507	335	842	79.8	0.1576
CARACAL	175	113.7	18/3.61	1/3.61	18.05	184.2	10.24	194.5	507	81	587	41.1	0.1563
PANTHER	200	129	30/3.00	7/3.00	21	212.1	49.48	261.6	586	388	974	92.3	0.1363
LION	225	145	30/3.18	7/3.18	22.26	238.3	55.60	293.9	659	436	1095	100.5	0.1212
BEAR	250	161	30/3.35	7/3.35	23.45	264.4	61.70	326.1	730	483	1213	111.2	0.1093
GOAT	300	194	30/3.71	7/3.71	25.97	324.3	75.67	400.0	896	593	1489	135.8	0.0891
SHEEP	350	226	30/3.99	7/3.99	27.93	375.1	87.53	462.6	1034	684	1718	156.3	0.0770
ANTELOPE	350	226	54/2.97	7/2.97	26.73	374.1	48.49	422.6	1032	379	1411	118.5	0.0773
BISON	350	226	54/3.00	7/3.00	27	381.7	49.48	431.2	1056	388	1444	120.9	0.0757
JAGUAR	200	130	18/3.86	1/3.86	19.3	210.6	11.70	222.3	580	91	671	46.6	0.1367
DEER	400	258	30/4.27	7/4.27	29.89	429.6	100.20	529.8	1186	785	1971	178.5	0.0673
ZEBRA	400	258	54/3.18	7/3.18	28.62	428.9	55.60	484.5	1186	435	1621	131.9	0.0674
ELK	450	290	30/4.50	7/4.50	31.5	477.1	111.30	588.4	I318	872	2190	198.3	0.0606
CAMEL	450	290	54/3.35	7/3.35	30.15	475.9	61.70	537.6	I314	483	1797	145.9	0.0607
MOOSE	500	323	54/3.53	7/3.53	31.77	528.5	68.51	597.0	1462	537	1999	161.0	0.0547

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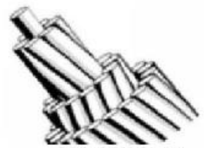

CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)

Code Name	Area				Equivalent copper area		Stranding and wire diameter		Approx. overall diameter	Weight			Rated Strength	Maximum DC resistance at 20 °C
	Aluminium		Steel	Total										
	AWG or MCM	mm²	mm²	mm²	AWG or MCM	mm²	Aluminium mm	Steel mm	mm	Aluminium kg/km	Steel kg/km	Total kg/km	kN	Ω / km
Wren	8	8.34	1.39	9.7	10	5.1	6/1.33	1/1.33	3.99	23	11	34	3.29	3.4416
Warbler	7	10.6	1.77	12.4	9	6.5	6/1.50	1/1.50	4.50	29	14	43	4.19	2.7057
Turkey	6	13.3	2.22	15.5	8	8.1	6/1.68	1/1.68	5.04	37	17	54	5.19	2.1569
Thrush	5	16.83	2.81	19.6	7	10.3	6/1.89	1/1.89	5.67	46	22	68	6.56	1.7043
Swan	4	21.18	3.53	24.7	6	12.9	6/2.12	1/2.12	6.36	58	27	85	8.15	1.3545
Swallow	3	26.69	4.45	31.1	5	16.3	6/2.38	1/2.38	7.14	73	35	108	10	1.0747
Sparrow	2	33.59	5.6	39.2	4	20.5	6/2.67	1/2.67	8.01	92	44	136	12.4	0.854
Robin	1	42.41	7.07	49.5	3	25.9	6/3.00	1/3.00	9.00	116	55	171	15.5	0.6764
Raven	1/0	53.52	8.92	62.4	2	32.6	6/3.37	1/3.37	10.11	146	69	215	18.9	0.536
Quail	2/0	67.33	11.22	78.6	I	41.1	6/3.78	1/3.78	11.34	185	88	273	23.5	0.4261
Pigeon	3/0	85.11	14.18	99.3	1/0	51.9	6/4.25	1/4.25	12.75	233	110	343	29.6	0.337
Penguin	4/0	107.2	17.87	125.1	2/0	65.4	6/4.77	1/4.77	14.31	294	139	433	37.3	0.2676
Owl	266.8	135.4	17.6	153.0	3/0	82.6	6/5.36	7/1.79	16.09	371	137	508	41	0.2119
Waxwing	266.8	135	7.5	142.5	3/0	82.3	18/3.09	1/3.09	15.45	372	58	430	31.2	0.2134
Partridge	266.8	134.9	22	156.9	3/0	82.3	26/2.57	7/2.00	16.28	374	171	545	49.3	0.2141
Phoebe	300	152.1	8.46	160.6	189	92.8	18/3.28	1/3.28	16.40	418	65	483	35.2	0.1894
Ostrich	300	152.2	24.1	176.9	189	92.8	26/2.73	7/2.12	17.28	420	193	613	55.6	0.1897
Piper	300	152	35.5	187.5	189	92.7	30/2.54	7/2.54	17.78	420	277	697	66.3	0.1899
Merlin	336.4	170.2	9.45	179.7	4/0	103.8	18/3.47	1/3.47	17.35	469	74	543	39.3	0.1692
Linnet	336.4	170.6	27.83	198.4	4/0	104	26/2.89	7/2.25	18.31	470	217	687	61.6	0.1693
Oriole	336.4	170.5	39.78	210.3	4/0	104	30/2.69	7/2.69	18.83	472	311	783	76	0.1694
Chickadee	397.5	200.9	11.16	212.1	250	122.6	18/3.77	1/3.77	18.85	555	86	641	45.4	0.1433

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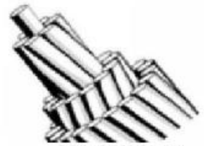
CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)



CSA-CAN Sizes

Code Name	Area: Aluminium AWG or MCM	Area: Aluminium mm^2	Area: Steel mm^2	Area: Total mm^2	Equivalent copper area AWG or MCM	Equivalent copper area mm^2	Stranding and wire diameter: Aluminium mm	Stranding and wire diameter: Steel mm	Approx. overall diameter mm	Weight: Aluminium kg/km	Weight: Steel kg/km	Weight: Total kg/km	Rated Strength kN	Maximum DC resistance at 20 °C Ω / km
Ibis	397.5	201.3	32.73	234.0	250	122.8	26/3.14	7/2.44	19.88	557	256	813	70.2	0.1434
Lark	397.5	200.9	46.87	247.8	250	122.5	30/2.92	7/2.92	20.44	557	366	923	88.6	0.1437
Pelican	477	242.3	13.46	255.8	300	147.8	18/4.14	1/4.14	20.70	665	104	769	54.8	0.1189
-	477	241.8	23.78	265.6	300	147.4	22/3.74	7/2.08	21.20	667	186	853	67.3	0.1193
Hawk	477	241.6	39.19	280.8	300	147.4	26/3.44	7/2.67	21.77	667	308	975	84.2	0.1195
Hen	477	241.3	56.29	297.6	300	142.2	30/3.20	7/3.20	22.40	668	440	1108	102.9	0.1197
Heron	500	253.5	59.1	312.6	315	155	30/3.28	7/3.28	22.96	700	464	1164	108.16	0.11391
Sapsucker	556.5	282	27.6	309.6	350	172	22/4.04	7/2.24	22.88	778	216	994	78.81	0.1027
Dove	556.5	282.6	45.9	328.5	350	172	26/3.72	7/2.89	23.55	781	360	1141	100.39	0.10218
Eagle	556.5	282.1	65.8	347.9	350	172	30/3.46	7/3.46	24.22	779	516	1295	120.35	0.10236
Teal	605	306.3	30.1	336.4	381	187	22/4.21	7/2.34	23.86	845	236	1081	84.35	0.09417
Duck	605	306.9	39.8	346.7	381	187	54/2.69	7/2.69	24.21	849	312	1161	100.54	0.09424
----	636	322.5	31.7	354.2	400	197	22/4.32	7/2.40	24.48	890	248	1138	89.31	0.08944
Grosbeak	636	321.8	52.5	374.3	400	196	26/3.97	7/3.09	25.15	889	411	1300	110.85	0.08972
Egert	636	322.6	73.5	396.1	400	197	30/3.70	19/2.22	25.90	891	579	1470	140.88	0.08952
Goose	636	323.1	41.9	365.0	400	197	54/2.76	7/2.76	24.84	894	328	1222	104.28	0.08952
----	666.6	337.8	17.4	355.2	419	206	42/3.20	7/1.78	24.54	934	137	1071	77.8	0.08554
Gull	666.6	337.3	43.7	381.0	419	206	54/2.82	7/2.82	25.38	934	342	1276	108.86	0.08575
Starling	715.5	361.9	59.2	421.1	450	221	26/4.21	7/3.28	26.68	1000	464	1464	124.78	0.07978
Redwing	715.5	362.1	82.4	444.5	450	221	30/3.92	19/2.35	27.43	1001	648	1649	153.69	0.07975
----	715.5	361.4	18.6	380.0	450	220	42/3.31	7/1.84	25.38	999	146	1145	83.22	0.07995

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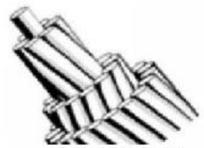
CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)



CSA-CAN Sizes

Code Name	Area				Equivalent copper area		Stranding and wire diameter		Approx. overall diameter	Weight			Rated Strength	Maximum DC resistance at 20 °C
	Aluminium		Steel	Total										
	AWG or MCM	mm^2	mm^2	mm^2	AWG or MCM	mm^2	Aluminium mm	Steel mm	mm	Aluminium kg/km	Steel kg/km	Total kg/km	kN	Ω / km
Crow	715.5	361.6	46.9	408.5	450	221	54/2.92	7/2.92	26.28	1001	367	1368	116.72	0.07998
Drake	795	402.6	65.4	468.0	500	246	26/4.44	7/3.45	28.11	1112	513	1625	138.4	0.07173
Mallard	795	403.8	91.8	495.6	500	246	30/4.14	19/2.48	28.96	1116	722	1838	171.46	0.0715
----	795	404.1	20.7	424.8	500	247	42/3.50	7/1.94	26.82	1117	163	1280	92.9	0.0715
Condor	795	402.3	52.2	454.5	500	245	54/3.08	7/3.08	27.72	1114	409	1523	125.77	0.07189
----	874.5	444.3	22.9	467.2	550	271	42/3.67	7/2.04	28.14	1229	179	1408	102.3	0.06503
Crane	874.5	442.5	57.4	499.9	550	270	54/3.23	7/3.23	29.07	1229	499	1674	138.36	0.06537
----	900	456.5	23.6	480.1	566	279	42/3.72	7/2.07	28.53	1262	185	1447	105.16	0.0633
Canary	900	456.3	59.1	515.4	566	278	54/3.28	7/3.28	29.52	1263	464	1727	142.63	0.06339
----	954	483.9	24.9	508.8	600	295	42/3.83	7/2.13	29.37	1338	195	1533	109.02	0.05977
Cardinal	954	484.5	62.8	547.3	600	296	54/3.38	7/3.38	30.42	1341	492	1833	151.46	0.05969
----	1033.5	525.1	26.9	552.0	650	320	42/3.99	7/2.21	30.57	1452	210	1662	118.07	0.05502
Curlew	1033.5	522.5	67.7	590.2	650	319	54/3.51	7/3.51	31.59	1446	531	1977	163.33	0.05535
----	1113	565.4	29.1	594.5	700	345	42/4.14	7/2.30	31.74	1563	228	1791	126.44	0.05114
Finch	1113	565	71.6	636.6	700	345	54/3.65	19/2.19	32.85	1564	563	2127	179.79	0.05119
---	1192.5	604.4	31.3	635.7	750	369	42/4.28	7/2.38	32.82	1670	243	1913	135.2	0.04778
Grackle	1192.5	602.8	76.89	679.7	750	368	54/3.77	19/2.27	33.97	1667	602	2269	189.4	0.04798
Scissomil	1272	644.3	33.3	677.6	800	393	42/4.42	7/2.46	33.90	1780	260	2040	144.3	0.04484
Pheasant	1272	645.3	81.7	727.0	800	394	54/3.90	19/2.34	35.10	1784	640	2424	199.6	0.04484
---	1351.5	685.9	35.2	721.1	850	418	42/4.56	7/2.53	34.95	1895	275	2170	153.3	0.04213
Martin	1351.5	685.3	86.7	772.0	850	418	54/4.02	19/2.41	36.17	1895	679	2574	211.9	0.0422
---	1431	725.8	37.5	763.3	900	443	42/4.69	7/2.61	35.97	2005	292	2297	162.4	0.03982

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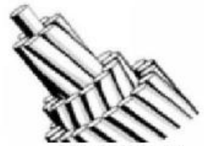
CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)



CSA-CAN Sizes

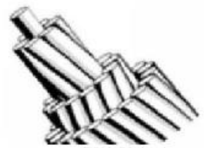
Code Name	Area – Aluminium AWG or MCM	Area – Aluminium mm²	Area – Steel mm²	Area – Total mm²	Equivalent copper area AWG or MCM	Equivalent copper area mm²	Stranding and wire diameter – Aluminium mm	Stranding and wire diameter – Steel mm	Approx. overall diameter mm	Weight – Aluminium kg/km	Weight – Steel kg/km	Weight – Total kg/km	Rated Strength kN	Maximum DC resistance at 20 °C Ω / km
Plover	1431	726.8	91.2	818.0	900	443	54/4.14	19/2.48	37.24	2010	719	2729	224.6	0.03979
---	1510.5	766.5	39.2	805.7	950	468	42/4.82	7/2.67	36.93	2117	306	2423	171.1	0.0377
Parrot	1510.5	766.3	97	863.3	950	467	54/4.25	19/2.55	38.25	2119	760	2879	237	0.03775
---	1590	804.5	71.3	875.8	1000	491	48/4.62	7/3.60	38.52	2222	556	2778	211.1	0.036
Falcon	1590	806.2	102.4	908.6	1000	492	54/4.36	19/2.62	39.26	2230	802	3032	249.8	0.03587
---	1590	803.5	34.9	838.4	1000	490	72/3.77	7/2.52	37.72	2222	273	2495	172.4	0.03598
Extra High Strength Strandings														
Bantam	13.1	6.65	8.86	15.5	8.26	4.1	3/1.68	4/1.68	5.04	18.2	69.6	87.8	12.3	4.3139
Magpie	20.87	10.59	14.12	24.7	13.13	6.5	3/2.12	4/2.12	6.36	29	110.7	139.7	18.5	2.709
Shrike	33.2	16.8	22.39	39.2	20.87	10.2	3/2.67	4/2.67	8.01	46.1	176.5	222.6	28.6	1.7079
Snipe	52.825	26.76	35.68	62.4	33.18	16.3	3/3.37	4/3.37	10.11	73.4	280.7	354.1	43.8	1.0721
Loon	66.5	33.66	44.89	78.6	41.84	20.6	3/3.78	4/3.78	11.34	92.4	353.4	445.8	56.1	0.8521
Grouse	80	40.54	14.12	54.7	50.31	24.7	8/2.54	1/4.24	9.32	111.2	110	221.2	22.8	0.7078
Petrel	101.8	51.61	30.1	81.7	64.16	31.5	12/2.34	7/2.34	11.70	142.1	234.8	376.9	43.9	0.5614
Minorca	110.8	56.11	32.73	88.8	69.7	34.2	12/2.44	7/2.44	12.20	155.6	255.7	411.3	47.7	0.5163
Leghorn	134.6	68.19	39.78	108.0	84.6	41.6	12/2.69	7/2.69	13.45	187.5	311	498.5	57.6	0.4248
Guinea	159	80.36	46.88	127.2	100	49	12/2.92	7/2.92	14.60	221.7	366.1	587.8	67.5	0.3605
Dotterel	176.6	89.41	52.15	141.6	111.2	54.5	12/3.08	7/3.08	15.40	247	407.8	654.8	72.6	0.324
Dorking	190.8	96.51	56.3	152.8	120	58.9	12/3.20	7/3.20	16.00	266.4	439.5	705.9	78.3	0.3002
Brahma	203.2	102.8	91.78	194.6	127.8	62.7	16/2.86	19/2.48	18.12	285.7	718.8	1004.5	122.6	0.2818
Auk	203	103.1	27.83	130.9	127.7	62.9	8/4.05	7/2.25	14.85	282.7	217.3	500	49.6	0.2784
Cochin	211.3	107	62.44	169.4	132.9	65.3	12/3.37	7/3.37	16.85	294.7	488.1	782.8	86.9	0.2704

CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)

DIN Sizes

Area					Equivalent copper area	Stranding and wire diameter		Overall Diameter	Weight			Calculated breaking load	Maximum DC resistance at 20 °C
Nominal													
Aluminium	Steel	Aluminium	Steel	Total		Aluminium	Steel		Aluminium	Steel	Total		
mm^2	mm^2	mm^2	mm^2	mm^2	mm^2	mm	mm	mm	kg/km	kg/km	kg/km	kN	Ω / km
16	2.5	15.3	2.6	17.9	9.3	6/1.80	1/1.80	5.4	41.8	19.9	61.7	5.81	1.8793
25	4.0	23.8	4.0	27.8	14.5	6/2.25	1/2.25	6.8	65.4	31.0	96.4	9.02	1.2028
35	6.0	34.3	5.7	40.0	20.9	6/2.70	1/2.70	8.1	94.2	44.7	138.9	12.70	0.8353
44	32.0	44.0	31.7	75.7	26.8	14/2.00	7/2.40	11.2	121.4	248.2	369.6	45.46	0.6573
50	8.0	48.3	8.0	56.3	29.5	6/3.20	1/3.20	9.6	132.2	62.7	194.9	17.18	0.5946
50	30	51.2	29.8	81.0	31.2	12/2.33	7/2.33	11.7	141.1	233.9	375.0	44.28	0.5644
70	12	69.9	11.4	81.3	42.6	26/ I .85	7/1.44	11.7	192.8	89.4	282.2	26.31	0.41 30
95	15	94.4	15.3	109.7	57.6	26/2. I 5	7/1.67	13.6	260.3	120.1	380.4	35.17	0.3058
95	55	96.5	56.3	152.8	58.9	12/3.20	7/3.20	16.0	266.2	441.1	707.3	80.20	0.2992
105	75	105.7	75.5	181.5	64.5	14/3.10	19/2.25	17.5	291.8	594.0	885.8	106.69	0.2376
120	20	121.6	19.8	141.4	74.2	26/2.44	711 .90	15.5	335.5	155.5	491.0	44.94	0.2374
120	70	122.0	71.3	193.3	74.4	12/3.60	7/3.60	18.0	337.0	558.0	895.0	98.16	0.2364
125	30	127.9	29.8	157.7	78.0	30/2.33	7/2.33	16.1	353.0	233.9	586.9	57.86	0.2259
150	25	148.9	24.2	173.1	90.8	26/2.70	7/2.10	17.1	410.6	190.0	600.6	54.37	0.1939
170	40	171.8	40.1	211.9	104.8	30/2.70	712.7	18.9	474.2	314.0	788.2	77.01	0.1682
185	30	183.8	29.8	213.6	112.1	26/3.00	7/2.33	19	507.0	233.9	740.9	66.28	0.1571

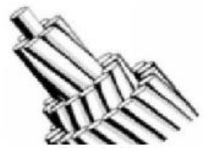
CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)



DIN Sizes

Area					Equivalent copper area	Stranding and wire diameter		Overall Diameter	Weight			Calculated breaking load	Maximum DC resistance at 20 °C
Nominal													
Aluminium	Steel	Aluminium	Steel	Total		Aluminium	Steel		Aluminium	Steel	Total		
mm^2	mm^2	mm^2	mm^2	mm^2	mm^2	mm	mm	mm	kg/km	kg/km	kg/km	kN	Ω / km
210	35	209.1	34.1	243.2	128	26/3.20	7/2.49	20.3	576.6	267.1	843.7	74.94	0.1380
210	50	212.1	49.5	261.6	129	30/3.00	7/3.00	21.0	585.5	387.7	973.2	92.23	0.1363
230	30	230.9	29.8	260.7	141	24/3.50	7/2.33	21.0	636.5	233.9	870.4	73.09	0.1249
240	40	243.0	39.5	282.5	148	26/3.45	7/2.68	21.8	670.4	309.4	979.8	86.46	0.1188
265	35	263.7	34.1	297.8	161	24/3.74	7/2.49	22.4	726.9	267.1	994.0	82.94	0.1094
300	50	304.3	49.5	353.7	186	26/3.86	7/3.00	24.5	839.0	387.7	1226.7	105.09	0.0949
305	40	304.6	39.5	344.1	186	54/2.68	7/2.68	24.1	841.2	309.4	1150.6	99.30	0.0949
340	30	339.3	29.8	369.1	207	48/3.00	7/2.33	25.0	936.8	233.9	1170.7	92.56	0.0851
380	50	382.0	49.5	431.5	233	54/3.00	7/3.00	27.0	1054.3	387.7	1442.0	120.91	0.0757
385	35	386.0	34.1	420.1	235	48/3.20	7/2.49	26.7	1065.4	267.1	1332.5	194.31	0.0748
435	55	434.3	56.3	490.6	265	54/3.20	7/3.20	28.8	1199.0	441.1	1631.1	136.27	0.0666
450	40	448.7	39.5	488.2	274	48/3.45	7/2.68	28.7	1238.6	309.4	1548.0	120.19	0.0644
490	65	490.3	63.6	553.9	299	54/3.40	7/3.40	30.6	1353.7	498.0	1851.7	152.85	0.0590
550	70	550.0	71.3	621.3	336	54/3.60	7/3.60	32.4	1518.3	558.3	2076.6	167.42	0.0526
560	50	561.7	49.5	611.2	343	48/3.86	7/3.00	32.2	1550.2	387.7	1937.9	146.28	0.0514
680	85	678.6	86.0	764.6	414	54/4.00	19/2.40	36.0	1874.5	675.8	2550.3	209.99	0.0426

CONDUCTOR DATA SHEET
ALUMINUM CONDUCTORS STEEL REINFORCED (ACSR)



French Sizes

Code Name	Total area			Equivalent copper area	Stranding and wire diameter		overall diameter	Weight			Rated Strength	Maximum dc resistance at 20 °C
	Aluminium	Steel	Total		Aluminium	Steel		Aluminium	Steel	Total		
	mm^2	mm^2	mm^2	mm^2	mm	mm	mm	kg/km	kg/km	kg/km	kN	Ω / km
Canna 37.7	28.27	9.42	37.69	17.2	9/2.0	3/2.0	8.3	78	77	155	1625	1.020
Canna 59.7	37.30	21.99	59.29	22.8	12/2.0	7/2.0	10.0	104	172	276	3270	0.766
Canna 75.5	47.71	27.83	75.54	29.1	12/2.25	7/2.25	11.25	131	218	349	4115	0.605
Canna 93.3	58.9	34.34	93.3	36.0	12/2.5	7/2.5	12.50	162	269	431	4950	0.490
Canna 116.2	94.25	21.99	116.24	57.5	30/2.0	7/2.0	14.0	260	172	432	4315	0.306
Canna 147.1	119.28	27.83	147.11	72.8	30/2.25	7/2.25	15.75	329	218	547	5400	0.2430
Crocus 147.1	119.28	27.83	147.11	72.8	30/2.25	7/2.25	15.75	329	218	547	6180	0.2430
Canna 181.6	147.26	34.26	181.62	89.8	30/2.5	7/2.5	17.5	406	269	675	6490	0.1970
Canna 228	184.72	43.10	227.82	112.7	30/2.8	7/2.8	19.6	512	338	847	8050	0.1570
Crocus 228	184.72	43.10	227.82	112.7	30/2.8	7/2.8	19.6	510	338	847	9210	0.1570
Canna 288	233.8	54.55	288.35	142.6	30/3.15	7/3.15	22.05	645	426	1071	9850	0.1240
Crocus 288	233.8	54.55	288.35	142.6	30/3.15	7/3.15	22.05	645	426	1071	11380	0.1240
Crocus 297	221.67	75.54	297.21	135.2	36/2.8	19/2.25	22.45	618	592	1210	14720	0.1310
Crocus 412	325.72	85.95	411.67	198.7	32/3.6	19/2.4	26.4	906	674	1580	17330	0.0890
Crocus 612	507.83	104.79	611.8	309.8	66/4.24	19/2.65	32.03	1408	822	2230	23150	0.0571
Crocus 865	717.33	148.06	865.4	437.9	66/3.72	19/3.15	38.01	1990	1161	3151	31900	0.0404
Crocus 1185	956.66	227.82	1185	583.6	54/2.80 +	37/2.8	44.7	2668	1792	4460	48050	0.0304

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