Stručna komisija 1 / Expert Committee 1
KOMPONENTE MREŽA / NETWORK COMPONENTS

Predsednik komisije: dr Vladimir ŠILJKUT, Elektroprivreda Srbije AD Beograd, Srbija

The Committee Chairman: Dr. Vladimir ŠILJKUT, JSC Elektroprivreda Srbije Belgrade, Serbia

Za XIV Savetovanje o elektrodistributivnim mrežama u organizaciji CIRED-SRBIJA, za Stručnu komisiju 1 – *Komponente mreža* inicijalno su prijavljene teme za 24 rada, od kojih su, na osnovu dostavljenih kratkih sadržaja (rezimea), prihvaćene 22, dok su dve preusmerene na STK-3 i STK-4. U daljem postupku, autori su dostavili 21 kompletiran rad, od kojih je svaki recenziran od strane bar jednog zvaničnog recenzenta i predsednika STK. Dva rada su odbijena zbog negativnih konačnih recenzija, dok je autor jednog rada odlučio da ga sâm povuče, nakon dva ciklusa izmena koje su ocenjene kao nedovoljne.

Na osnovu preostalih, pozitivnih konačnih recenzija, STK-1 prihvatila je ukupno 18 radova, od kojih 12 pripadaju grupi referata, a preostalih šest tehničkim informacijama. Pet radova se bave nadzemnim vodovima, jedan rad uzemljivačkim sistemom podzemnih (kablovskih) vodova, pet radova razmatra problematiku u vezi sa transformatorskim stanicama, razvodnim postrojenjima i rasklopnim aparaturama, šest se odnosi na energetske transformatore i jedan na distribuiranu proizvodnju (solarne elektrane). Ovoga puta nije bilo radova koji bi za temu imali merne transformatore.

For the XIV Conference on Power Distribution Networks organized by CIRED-SERBIA, for Expert Committee 1 - Network Components, topics for 24 papers were initially submitted, 22 of which, based on the attached brief contents (abstracts), were accepted, while two were redirected to EC - 3 and EC - 4. In the further process, the authors submitted 21 completed papers, each of which was reviewed by at least one official reviewer and EC chairman. Two papers were rejected due to negative final reviews, while the author of one paper decided to withdraw it by himself, after two rounds of revisions that were deemed insufficient.

Based on the remaining, positive final reviews, EC - 1 accepted a total of 18 papers, 12 of which belong to the group of reports, and the remaining six to technical information. Five papers deal with overhead lines, one paper with the grounding system of underground (cable) lines, five papers consider problems related to substations, switchgears and switching equipment, six refer to power transformers and one to distributed generation (solar power plants). This time there were no papers that had instrument transformers as their topic.

Preferencijalne teme (PT) i pod-teme za Stručnu komisiju 1 su:

1. *Komponente za napredne elektrodistributivne mreže i inovacije u dizajnu*
   - Savremene konstrukcije komponenti mreža
   - Primena novih i inovativnih tehničkih rešenja
   - Korišćenje novih materijala za izradu komponenti
   - Unapređenje standarda, tehničkih propisa, tehničkih i funkcionalnih specifikacija za komponente mreža
2. *Pouzdanost, dijagnostika i strategija održavanja komponenti mreža*
   - Pouzdanost, modeli starenja, procena stanja i životnog veka komponenti
   - Ispitivanje, monitoring i metode dijagnostike komponenti mreža
   - Praksa i strategija održavanja komponenti mreža
   - Produženje životnog veka, retrofit i unapređenje karakteristika postojećih komponenti
3. *Modelovanje komponenti i primena savremenih softverskih alata*
   - Modelovanje komponenti elektrodistributivnih mreža
   - Digitalizacija i „digitalni blizanci“ komponenti mreža
   - Primena savremenih softverskih alata za analizu komponenti elektrodistributivne mreže
   - Upotreba digitalnih alata, Big Data, veštačke inteligencije i mašinskog učenja
4. *Uticaj komponenti elektrodistributivnih mreža*
   - Uticaj komponenti mreža na životnu i radnu sredinu
   - Ograničenje vizuelnog i uticaja buke i elektromagnetskog zračenja
   - Cirkularna ekonomija, eko-dizajn, upotreba recikliranih materijala, analiza životnog ciklusa komponenti mreža
   - Upravljanje opasnim materijama u vezi sa komponentama mreža

Preferential topics (PT) and sub-topics for Expert Committee 1 are:

1. *Components for advanced power distribution networks and innovations in design*
   - *Modern constructions of network components*
   - *Application of new and innovative technical solutions*
   - *Use of new materials for making components*
   - *Improvement of standards, technical regulations, technical and functional specifications for network components*
2. *Reliability, diagnostics and maintenance strategy for network components*
   - *Reliability, aging models, condition and assessment of component life*
   - *Testing, monitoring and diagnostic methods for network components*
   - *Practice and strategy for maintenance of network components*
   - *Life extension, retrofit and improvement of the characteristics of existing components*

3. *Components modelling and application of modern software tools*
   - *Modeling of electrical distribution network components*
   - *Network components digitization and "digital twins"*
   - *Application of modern software tools for electrical distribution network components analysis*
   - *Use of digital tools, Big Data, artificial intelligence and machine learning*
4. *The impact of electrical distribution networks components*
   - *Living and working environmenal impact caused by network components*
   - *Limitation of visual, noise and electromagnetic radiation impact*
   - *Circular economy, eco-design, use of recycled materials, life cycle analysis of network components*
   - *Hazardous materials risk management related to network components*

Za prvu preferencijalnu temu prihvaćena su tri rada i svi su svrstani u kategoriju tehničkih informacija.

Druga preferencijalna tema je razmatrana u šest radova, od kojih pet pripadaju kategoriji referata, a jedan je okarakterisan kao informacija.

U trećoj preferencijalnoj temi je takođe šest radova, pet su ocenjeni kao referati dok je jedan okarakterisan kao informacija.

Za četvrtu preferencijalnu temu prihvaćeno je tri rada, od kojih su dva svrstana u kategoriju referata, a jedan je informacija.

Statistika rezimea i statusa radova, po preferencijalnim temama, prikazana je na Slici 1. Slika 2 prikazuje broj prihvaćenih radova po komponentama mreže i preferencijalnim temama, a Slika 3 broj referata i informacija po preferencijalnim temama.

For the first preferential topic, three papers were accepted and all were classified in the category of technical information.

The second preferential topic was discussed in six papers, five of which belong to the report category, and one is characterized as information.

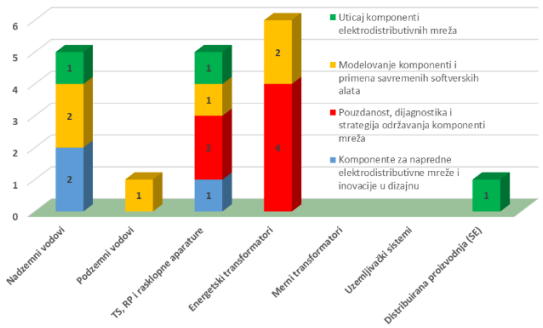
In the third preferential topic, there were also six papers, five of which were rated as reports while one was characterized as information.

For the fourth preferential topic, three papers were accepted, two of which were assigned to the report category, and one was information.

Statistics of the summaries (abstracts) and status of papers, by preferential topics, are shown in Figure 1. Figure 2 shows the number of accepted papers by network components and preferential topics, and Figure 3 the number of reports and information by preferential topics.

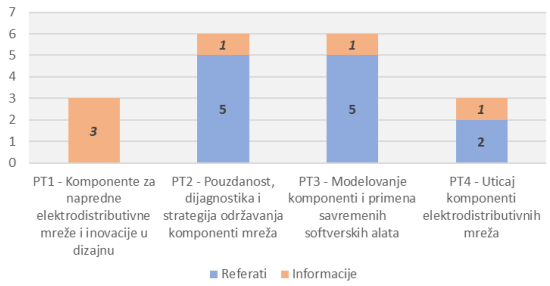
Slika 1 Statistika rezimea i statusa radova (levo: promene od prijave do konačnog ocenjivanja; desno: konačno stanje)

Figure 1 Summary and status statistics of papers (left: changes from submission to final evaluation; right: final state)



Slika 2 Broj prihvaćenih radova po komponentama mreže i preferencijalnim temama

Figure 2 Number of accepted papers by network components and preferential topics



Slika 3 Broj referata i informacija po preferencijalnim temama

Figure 3 Number of reports and information by preferential topics

Što se tiče pripadnosti (afilijacijâ) autora i koautora prihvaćenih radova, njihova raspodela prikazana je na Slici 4. Jedan autor je naveo dve pripadnosti (energetskom subjektu i fakultetu), pa je iz tog razloga u ovim kategorijama naveden decimalan broj. Plavi stubovi na Slici 4 prikazuju ukupan broj (ko)autora na radovima, bez obzira na to da li se identitet (ko)autora ponavlja na dva ili više radova, a crveni stubovi vodeći računa o tome, dakle – prikazuju stvaran broj (ko)autora, po imenu i prezimenu.

Kada se posmatra kako broj prijavljenih tema i kratkih sadržaja, tako i broj prihvaćenih kompletiranih radova na ovom i prethodna dva savetovanja, primetan je jasan opadajući trend, i jednog i drugog broja. Ovi trendovi su ilustrovani na Slici 5.

Što se tiče analize po preferencijalnim temama, od ovog Savetovanja (2024.) nekadašnja peta preferencijalna tema postala je poslednja pod-tema prve preferencijalne teme, tako da je – radi korektnog poređenja – raniji (2020/21. i 2022.) broj radova iz pete preferencijalne teme pridodat broju radova u prvoj preferencijalnoj temi. Trendovi (2020-2024) broja prijavljenih rezimea i broja radova po preferencijalnim temama prikazani su na slikama 6 i 7, respektivno.

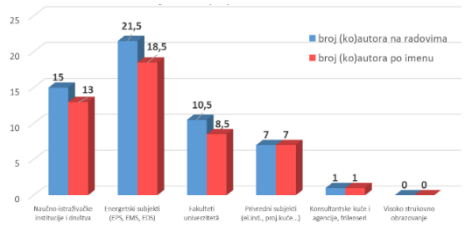
Trendovi broja prijavljenih rezimea i broja radova po komponentama mreže prikazani su na slikama 8 i 9, respektivno.

Regarding the affiliation of authors and co-authors of accepted papers, their distribution is shown in Figure 4. One author stated two affiliations (an energy subject and a faculty), and for that reason a decimal number is indicated in these categories. The blue columns in Figure 4 show the total number of (co)authors of the papers, regardless of whether the identity of the (co)author is repeated in two or more papers, and the red columns taking this into account thereof, therefore – they show the real number (who) author, by name and surname.

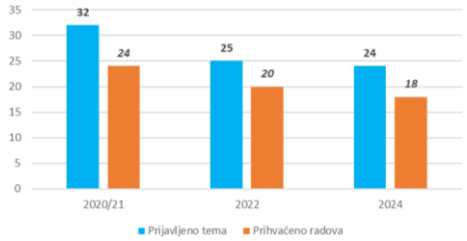
When looking at both the number of submitted topics and summaries, as well as the number of accepted completed papers at this and the previous two conferences, a clear downward trend is apparent, concerning both. These trends are illustrated in Figure 5.

As for the analysis by preferential topics, starting from this Conference (2024) the former fifth preferential topic has become the last sub-topic of the first preferential topic. Hence, for the sake of acurate comparison - the earlier (2020/21 and 2022) number of papers from the fifth preferential topic has been added to the number of papers in the first preferential topic. The trends (2020-2024) of the number of submitted summaries and the number of papers by preferential topics is shown in Figures 6 and 7, respectively.

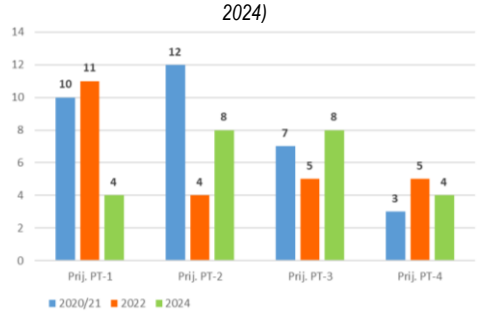
Trends in the number of submitted abstracts and the number of papers by network components are shown in Figures 8 and 9, respectively.



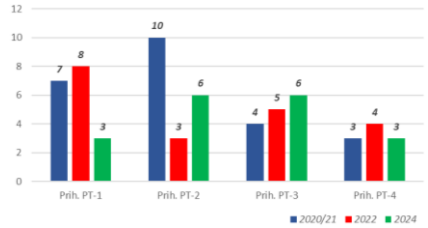
Slika 4 Afilijacije (ko)autora
Figure 4 Affiliations of (co)authors



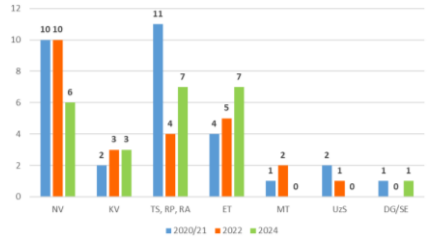
Slika 5 Broj tema/rezimea i broj radova (2020-2024)
Figure 5 Number of topics/summaries and number of papers (2020-2024)



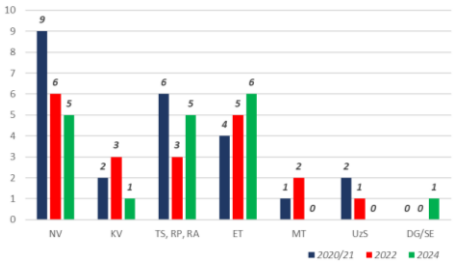
Slika 6 Broj prijavljenih rezimea po preferenc. temama
Figure 6 Number of reported summaries by preferencial topics



Slika 7 Broj prihvaćenih radova po preferenc. Temama
Figure 7 Number of papers accepted by preferencial topics



Slika 8 Broj prijavljenih rezimea po komponenti mreže
Figure 8 Number of reported summaries per network components



Slika 9 Broj prihvaćenih radova po komponent. mreže
Figure 9 Number of accepted papers per network components

IZVEŠTAJ STRUČNIH IZVESTILACA / EXPERT REVIEWERS REPORT

STK 1 / *EC 1*: Preferencijalna tema 1 / *Preferential Subject 1*:
Komponente za napredne elektrodistributivne mreže i inovacije u dizajnu
Components for smart distribution grids and innovations in design

I-1.01
HIBRIDNI IZOLATORI ZA DISTRIBUTIVNE NADZEMNE VODOVE
HYBRID INSULATORS FOR OVERHEAD DISTRIBUTION LINES
Vladimir Alempijević, Dimitrije Anđelković

U radu je dat prikaz konstrukcije hibridnih izolatora i njihove prednosti u odnosu na izolatore od silikonizovane gume i izolatore od keramike.

The paper presents the construction of hybrid insulators and their advantages in comparison to siliconized rubber insulators and ceramic insulators.

Pitanja za diskusiju / *Questions for discussion*

1. U radu je navedeno da su se u našoj distributivnoj mreži hibridni izolatori koristili samo kao pilot projekti. Gde su ugrađivani, zašto baš na tim lokacijama, u kom obimu i da li već postoje iskustva iz eksploatacije?
2. Dati uporedni prikaz cena izolatora od keramike, izolatora od silikonizovane gume i hibridnih izolatora, za nekoliko najčešće korišćenih tipova izolatora na različitim naponskim nivoima.
3. Da li se u Srbiji proizvode hibridni izolatori?

1. *It was stated in the paper that in our distribution network hybrid insulators were used only as pilot projects. Where were they installed, why exactly in those locations, to what extent and are there already experiences from exploitation?*
2. *To provide a comparative view of the prices of ceramic insulators, siliconized rubber insulators and hybrid insulators, for several commonly used insulator types at different voltage levels.*
3. *Are hybrid insulators produced in Serbia?*

I-1.02.
KOORDINACIJA NAPONA I IZOLACIJE ZA DISTRIBUTIVNU NADZEMNU MREŽU NAZIVNOG NAPONA 35 KV
VOLTAGE AND INSULATION COORDINATION OF 35 KV NOMINAL VOLTAGE OVERHEAD DISTRIBUTION NETWORK
Alen Gudžević, Darko Maleš, Biljana Stojanović

U radu je dat uporedni prikaz povučenih standarda i novih usvojenih koji se odnose na standardne napone i koordinaciju izolacije.

The paper provides a comparative overview of withdrawn standards and newly adopted standards related to standard voltages and insulation coordination.

Pitanja za diskusiju / *Questions for discussion*

1. Potrebno je obrazložiti zaključak kojim se daje predlog da se za nadzemnu mrežu nazivnog napona 35 kV na teritoriji Republike Srbije i dalje koriste naponski nivoi iz povučenih standarda.

1. *It is necessary to explane the conclusion by which the proposal is made to continue to use the voltage levels from the withdrawn standards for the overhead network with a nominal voltage of 35 kV on the territory of the Republic of Serbia..*

I-1.03.
UPOTREBA REKLOZERA U RAZVODNIM POSTROJENJIMA KAO ALTERNATIVA KLASIČNIM REŠENJIMA ZA UNAPREĐENJE RASPLETA SREDNJENAPONSKE MREŽE
THE USE OF RECLOSERS IN SWITCHGEARS AS AN ALTERNATIVE TO CLASSICAL SOLUTIONS FOR IMPROVING THE SHAPE OF MEDIUM VOLTAGE NETWORK
Srbislav Sarić, Biljana Sarić

U radu su prikazane dve varijante raspleta mreže 20 kV uz upotrebu reklozera. Obe varijante raspleta su predviđene u okviru kompleksa sadašnje transformatorske stanice 35/10 kV Kuzmin, koja se u budućnosti gasi jer se ukida naponski nivo 35 kV. Prva varijanta zahteva manja ulaganja, dok druga varijanta zahteva veća ulaganja ali je bolja sa aspekta pouzdanosti. Obe varijante raspleta predviđaju takav raspored elemenata, koji ostavlja slobodan prostor u sredini kompleksa za moguću izgradnju buduće transformatorske stanice 110/20 kV.

The paper presents two variants of the 20 kV network re-shaping with the use of reclosers. Both variants of the re-shaping are planned within the complex of the current 35/10 kV Kuzmin substation, which will be shut down in the future because the voltage level of 35 kV should be abandon. The first variant requires smaller investments, while the second variant requires larger investments but is better from the aspect of reliability. Both variants of the re-shaping foresee such an arrangement of elements, which leaves free space in the middle of the complex for the possible construction of a future 110/20 kV substation.

Pitanja za diskusiju / *Questions for discussion*

1. Koliko je izvesna izgradnja TS 110/20 kV u kompleksu sadašnje TS 35/10 kV Kuzmin?
2. Da li se varijantama prikazanim u radu, obezbeđuje dovoljan prostor za izgradnju TS 110/20 kV?

1. *How certain is the construction of 110/20 kV substation (SS) in the complex of the current SS 35/10 kV Kuzmin?*
2. *Do the variants presented in the paper provide sufficient space for the construction of SS 110/20 kV?*

STK 1 / *EC 1*: Preferencijalna tema 2 / *Preferential Subject 2*:
Pouzdanost, dijagnostika i strategija održavanja komponenti mreža
Components reliability, diagnostics and maintenance strategy

R-1.04.
KVAROVI ENERGETSKIH TRANSFORMATORA KOJI SE NISU MOGLI POTVRDITI ELEKTRIČNIM ISPITIVANJIMA
FAILURES OF POWER TRANSFORMERS THAT COULD NOT BE CONFIRMED BY ELECTRICAL TESTS
Siniša Spremić, Aleksandar Antonić

U radu su opisana tri slučaja kvarova energetskih transformatora (ET) kod kojih prethodno sprovedena električna ispitivanja nisu pokazala neispravnost. U dva slučaja postojanja kvarova su utvrđena nakon otvaranja i pregleda energetskih transformatora, dok je u jednom slučaju kvar potvrđen poređenjem rezultata kapacitivnosti namotaja međusobno i prema masi ET u kvaru i drugog ispravnog ET istog tipa, a tačno mesto kvara nakon otvaranja ET.

The paper describes three cases of power transformer (ET) failures in which previously conducted electrical tests did not show any malfunction. In two cases of existence of failures, they were determined after opening and inspecting the power transformers, while in one case, the failure was confirmed by comparing the coil capacitance results with each other and according to the mass of the faulty ET and another correct ET of the same type, and the exact location of the failure after opening the ET.

Pitanja za diskusiju / *Questions for discussion*

1. Da li autori mogu objasne zašto pogrešna montaža savitljive veze nije mogla biti detektovana prethodno sprovedenim ispitivanjima?
2. U kojim slučajevima se snima SFRA?

1. *Can the authors explain why the incorrect assembly of the flexible connection could not be detected by the previously conducted tests?*
2. *In what cases is SFRA recorded?*

R-1.05.
KVAROVI REGULACIONIH SKLOPKI POD OPTEREĆENJEM
FAILURES OF ON-LOAD TAP CHANGERS
Goran Filipović, Aleksandar Antonić, Siniša Spremić

U radu je dat prikaz nekoliko posebnih slučajeva kvarova na regulacionim sklopkama distributivnih transformatora 110/x kV u DP Novi Sad. Pored detaljnog opisa, fotografija i rezultata gasnohromatografskih analiza svakog kvara, u zaključku se daje i predlog za dalji način održavanja regulacionih sklopki i motornih pogona.

The paper presents several special cases of failures on-load tap changers of 110/x kV distribution transformers in distribution area (DA) Novi Sad. In addition to the detailed description, photographs and results of gas chromatographic analyses of each failure, the conclusion also provides a proposal for further maintenance of tap changers and motor drives.

Pitanja za diskusiju / *Questions for discussion*

1. Da li se za navedene tipove regulacionih sklopki iz Tabele I može dati podatak o procentualnoj zastupljenosti svakog tipa u DP Novi Sad, kao i podatak o prosečnoj starosti pojedinih tipova?

1. *For the specified types of tap changers from Table I, is it possible to provide information on the representation percentage of each type in DA Novi Sad, as well as information on the average age of individual types?*

2. U radu je navedeno: „U dužem vremenskom razdoblju je jedan tip RS i pridruženih motornih pogona zamenjen u potpunosti zbog problema od početka korišćenja i lošeg kvaliteta. Nekim tipovima RS su zamenjeni svi motorni pogoni uz potrebna prilagođenja.“ Da li možete navesti koji su to tipovi i da li se može dati preporuka i drugim DP za preventivnu zamenu određenog tipa regulacionih sklopki, odnosno može li se dati preporuka za češći preventivni monitoring određenih tipova regulacionih sklopki?

3. U opisu kvara u poglavlju 3.1 je navedeno: “U početku je zbog lošeg kontakta postojalo grejanje koje se kasnije razvilo u manje varničenje čime je došlo do daljeg oštećenja dosednog kontakta. Kasnije je došlo do otpadanja viljuške sa oprugom u koju ulazi kontakt prekidačkog dela RS. To je na kraju dovelo do električnog luka, moguće prilikom promene položaja RS.” Koji je to period od pojave prvog grejanja do havarije? Da li se i kako mogao predvideti ovaj sled događaja i sprečiti pojava havarije na ovom transformatoru, koja je za posledicu, na kraju imala i rashodovanje transformatora?

2. It is stated in the paper: "Over a long period of time, one type of RS and associated motor drives was completely replaced due to problems from the beginning of use and poor quality. For some types of tap changers, all motor drives have been replaced with the necessary adjustments." Can you specify which types they are and whether it is possible to give a recommendation to other DAs for the preventive replacement of a certain type of tap changers, that is, whether it is possible to give recommendations for more frequent preventive monitoring of certain types of tap changers?

3. In the description of the failure in chapter 3.1, it is stated: "Initially, due to poor contact, heating, was present which later developed into minor sparking, causing further damage to the adjacent contact. Later on, the fork with the spring where the contact of the tap changers enters, fell off. This eventually caused an electric arc, possibly during the change in the tap changers position." What is the time duration from the occurence of the initial heating to the breakdown? Could this sequence of events have been foreseen and how could the breakdown of this transformer have been prevented, given that it ultimately resulted in the scrapping of the transformer?

R-1.06.
PRILIKA ZA UNAPREĐENJE ODRŽAVANJA TRANSFORMATORA 35/x KV
OPPORTUNITY FOR IMPROVING THE MAINTENANCE OF 35/x KV TRANSFORMERS
Vesna Radin, Branka Đurić, Đorđe Jovanović, Vladimir Ostraćanin, Radomir Todorović

U radu su prezentovana dva slučaja iz prakse na transformatorima 35/10 kV, gde je prilikom redovnog ispitivanja sadržaja gasova rastvorenih u ulju transformatora (kao alata za brzu detekciju kvara) izmeren porast koncentracije jednog ili više gasova. Ovo je ukazivalo na promenu temperaturnih uslova u transformatoru, koji su obično posledica kvara električne ili termičke prirode.

Nakon razrade kontakata na besteretnom regulatoru napona uočen je pad koncentracije pojedinih gasova. Može se zaključiti da je fizička manipulacija besteretnim regulatorom napona, u ova dva primera, dovela do spadanja nagomilanih naslaga koje su bile glavni uzrok pojave razlike u omskim otporima i posledičnog grejanja.

Autori rada, kao adekvatnu dodatnu meru održavanja transformatora, predlažu uvođenje periodične manipulacije besteretnim regulatorom što bi sprečilo ili u većoj meri smanjilo stvaranje naslaga na kontaktima i pojavu grejanja.

The paper presents two cases from practice on 35/10 kV transformers, where an increase in the concentration of one or more gases was measured during regular examination of the content of gases dissolved in the transformer oil (as a tool for quick fault detection). This indicated a change in temperature conditions in the transformer, which are usually the result of failure of electrical or thermal nature.

After working out the contacts on the no-load voltage regulator, a drop in the concentration of certain gases was observed. It can be concluded that the physical manipulation of the no-load voltage regulator, in these two examples, led to the fall of accumulated deposits, which were the main cause of the difference in ohmic resistances and the consequent heating.

The authors of the paper, as an adequate additional measure of transformer maintenance, propose the introduction of periodic manipulation of the no-load regulator, which would prevent or to a greater extent reduce the formation of deposits on the contacts and the occurrence of heating.

Pitanja za diskusiju / *Questions for discussion*

1. Da li je, pored prezentovana dva primera, bilo još sličnih slučajeva gde je nakon razrade kontakata na besteretnom regulatoru napona uočen pad koncentracije pojedinih gasova.

1. In addition to the two examples presented, have there been other similar cases where, after working out the contacts on the no-load voltage regulator, a drop in the concentration of certain gases was observed?

2. Autori rada, kao adekvatnu dodatnu meru održavanja transformatora, predlažu uvođenje periodične manipulacije besteretnim regulatorom. Koji je preporučen period, po mišljenju autora? Da li se ova mera predlaže za sve transformatore srednjeg napona, odnosno da li se predlaže i za transformatore koji prilikom redovnog ispitivanja sadržaja gasova rastvorenih u ulju transformatora imaju tipične vrednosti?

2. The authors of the paper, as an adequate additional measure of transformer maintenance, propose the introduction of periodic manipulation of the no-load regulator. What is the recommended period, according to the author? Is this measure proposed for all medium voltage transformers, or is it also proposed for transformers that have typical values during regular testing of the content of gases dissolved in the transformer oil?

R-1.07.

POSTUPAK ZA UKLANJANJE ELEMENTARNOG SUMPORA IZ ULJA ENERGETSKIH TRANSFORMATORA – SMANJENJE RIZIKA OD HAVARIJA ENERGETSKIH TRANSFORMATORA

PROCEDURE FOR REMOVING ELEMENTAL SULFUR FROM THE OIL OF POWER TRANSFORMERS - REDUCING THE RISK OF POWER TRANSFORMERS FAILURES

Dejan Kolarski, Valentina Vasović, Jelena Janković, Draginja Mihajlović, Jovana Bošnjaković

Prisustvo korozivnih sumpornih jedinjenja u mineralnom izolacionom ulju predstavlja jedan od uzroka havarija energetskih transformatora. Tema rada se odnosi na uklanjanje elementarnog sumpora iz mineralnog izolacionog ulja energetskih transformatora. U radu je prikazan niskotemperaturni postupak za uklanjanje elementarnog sumpora iz mineralnog izolacionog ulja koji je zasnovan na primeni male količine čestica gvožđa na čijoj površini je deponovan bakar, kao ključne komponente smeše reagensa koja je dispergovana u polietilen glikolu. Primenom prikazanog postupka dobijaju se izolaciona ulja sa poboljšanim fizičko-hemijskim i električnim karakteristikama pogodna za dalju upotrebu u energetskim transformatorima, pri čemu se smanjuju rizici od havarija energetskih transformatora.

The presence of corrosive sulphur compounds in mineral insulating oil is one of the causes of power transformer failures. The topic of the paper refers to the removal of elemental sulphur from the mineral insulating oil of power transformers. The paper presents a low-temperature process for the removal of elemental sulphur from mineral insulating oil, based on the application of a small amount of iron particles coated with copper on its surface as a key component of the reagent mixture which is dispersed in polyethylene glycol. With the application of this process, insulating oils with improved physical, chemical and electrical characteristics are obtained, suitable for further use in power transformers. The application of the procedure also reduces risks associated with power transformer failures.

Pitanja za diskusiju / *Questions for discussion*

1. Koje su prednosti postupka prikazanog u radu u odnosu na druge postupke za uklanjanje elementarnog sumpora?

1. *What are the advantages of the procedure presented in the paper compared to other procedures for the removal of elemental sulphur?*

R-1.08.

ONLINE MONITORING STANJA ELEKTROOPREME U RAZVODNIM POSTROJENJIMA

ELECTRICAL DISTRIBUTION ASSETS ONLINE CONDITION MONITORING

Denis Ilić, Damir Kopčanski

U radu su prikazani pristupi održavanja primenjujući sisteme za skladištenje podataka, uz sprovođenje naprednih tehnologija. Primerima iz prakse je ukazano koja poboljšanja se mogu sprovesti u postrojenjima kako bi se sprečili mogući ispadi.

The paper presents maintenance approaches applying data storage systems, with the implementation of advanced technologies. Examples from practice show which improvements can be implemented in plants in order to prevent possible outages.

Pitanja za diskusiju / *Questions for discussion*

1.Da li su vršene analize i kolika je ušteda ostvarena pri ugradnji monitoring sistema u srednjenaponskim i niskonaponskim postrojenjima?
2. Da li postoji primer iz prakse, na kojima je u prikazanom SN postrojenju u radu, uočeno da je došlo do povećane temperature, čime je sprečeno pomenuto zagrevanje i topljenje kontakata?

1. Have analyses been carried out and how much savings have been achieved when installing monitoring systems in medium and low voltage plants?
2. Is there an example from practice, where it was observed that in the shown MV switchgear in operation, increased temperature had occurred, which prevented the mentioned heating and melting of the contacts?

I-1.09.

REKONSTRUKCIJA 6,3 KV POSTROJENJA DOPREME UGLJA (2GD) U TERMOELEKTRANI KOSTOLAC A
RECONSTRUCTION OF 6,3 KV SWITCHGEAR OF DELIVERY OF COAL (2GD) IN THERMAL POWERPLANT KOSTOLAC A

Zlatko Simeunović, Jelena Nikolić, Dejan Žukovski, Miloš Stanisavljević

U radu se prikazuje da je rekonstrukcijom postrojenja 6,3 kV za dopremu uglja u TE Kostolac A postignut pouzdan i nesmetan rad postrojenja, kao i optimalna bezbednost osoblja. Konstatovano je takođe da su smanjeni troškovi održavanja postrojenja. S obzirom da je postrojenje povezano sa nadzorno-upravljačkim sistemom (SCADA) u elektrokomandi, to je značajno olakšalo praćenje rada postrojenja i upravljanje.

The paper shows that with the reconstruction of the 6.3 kV switchgear for coal delivery in TPP Kostolac A, reliable and smooth operation of the switchgear was achieved, as well as optimal safety of the personnel. It was also established that the maintenance costs of the switchgear were reduced. Considering that the switchgear is connected to the supervisory control system (SCADA) in the electrical control, it significantly facilitated the monitoring of the operation of the switchgear and the control.

Pitanja za diskusiju / *Questions for discussion*

1. Na osnovu čega ste se opredelili za optičku vezu zvezda umesto petlja koja je pouzdanija?
2. Objasniti prednosti uvođenja usmerene zemljospojne zaštite koja nije mogla biti uvedena pre rekonstrukcije.

1. *On what basis did you decide on a star optical connection instead of a loop, which is more reliable?*
2. *Explain the advantages of introducing directional earth fault protection, which could not be introduced before the reconstruction.*

STK 1 / *EC 1*: Preferencijalna tema 3 / *Preferential Subject 3*:
Modelovanje komponenti i primena savremenih softverskih alata
Components modeling and application of modern software tools

I-1.10

UPOREDNI PRIKAZ MODELOVANJA JEDNOFAZNOG KRATKOG SPOJA NA DALEKOVODU KORIŠĆENJEM SOFTVERSKOG PAKETA ATPDRAW I PRIMENOM IEC METODOLOGIJE
COMPARISON OF SINGLE PHASE SHORT CIRCUIT MODELLING BY USING OF ATPDRAW SOFTWARE AND IEC PROCEDURES

Aleksandar Terzić

U radu su prikazane metodologije modelovanja/proračuna jednofaznog kratkog spoja prema IEC standardima (bez potrebe korišćenja računara) i pomoću programa ATPdraw. Opisano je toplotno opterećivanje zaštitnog užeta sa (OPGW) tokom kratkog spoja.

The paper presents the modeling/calculation methodology of a single-phase short circuit according to IEC standards (without the need to use a computer) and using the ATPdraw program. The thermal loading of the protective wire with (OPGW) during a short circuit is described.

Pitanja za diskusiju / *Questions for discussion*

1. Da li je autor radio realne proračune sa obe metodologije i kakva su iskustva?
2. Kako se u ATPdraw obuhvata delovanje relejne zaštite?

1. *Has the author done real calculations using both methodologies and what are the experiences?*
2. *How is relay protection included in ATPdraw?*

R-1.11.

RAZVOJ SOFTVERA ZA IZBOR IZOLATORA I IZOLATORSKIH LANACA
DEVELOPMENT OF SOFTWARE FOR SELECTING INSULATORS AND INSULATOR STRINGS

Milica Vlaisavljević, Milan Obradović, Mileta Žarković

U radu je prikazan razvoj softvera za izbor izolatora i izolatorskih lanaca elektrodistributivnih vodova. Opisani su zahtevi za dimenzionisanje, algoritam i korisnički interfejs programa.

The paper presents the development of software for the selection of insulators and insulator chains of electrical distribution lines. The sizing requirements, algorithm and user interface of the program are described.

Pitanja za diskusiju / *Questions for discussion*

1. Mogu li autori u prezentaciji da prikažu izveštaj o rezultatima proračuna kao sastavnog dela projektne tehničke dokumentacije?
2. Da li je razvijeni program, kao i drugi programi čiji se razvoj planira, namenjen samo za internu upotrebu ili će biti komercijalno dostupan i drugim projektantima?

1. *In the presentation, can the authors present a report on the calculation results as an integral part of the project's technical documentation?*
2. *Is the developed program, as well as other programs whose development is planned, intended only for internal use or will it be commercially available to other designers?*

R-1.12.

PRORAČUN MINIMALNOG POPREČNOG PRESEKA PARALELNOG PROVODNIKA UZEMLJENJA ZA PODZEMNE ENERGETSKE KABLOVE U TROUGAONOJ FORMACIJI SA METALNIM EKRANIMA UZEMLJENIM NA JEDNOM KRAJU

CALCULATING MINIMUM CROSS-SECTIONAL AREA OF THE PARALLEL-EARTHING-CONDUCTOR FOR UNDERGROUND POWER CABLES IN TREFOIL FORMATION WITH METALLIC SCREENS BONDED AND EARTHED AT ONE END

Marko Šućurović, Dardan Klimenta, Dragan Tasić

Autori su u radu razmatrali primenu paralelnog provodnika uzemljenja (PPU) kod srednjenaponskih kablovskih vodova kao i načine za određivanje njegovog minimalnog poprečnog preseka. Nakon uvodnog dela, u radu su opisani različiti načini za povezivanje metalnih ekrana srednjenaponskih kablova kod kojih se koristi PPU. Zatim su objašnjena dva načina za određivanje minimalnog poprečnog preseka PPU kod srednjenaponskih kablova čiji su metalni ekrani uzemljeni samo na jednom kraju. U radu je dat i primer proračuna minimalnog poprečnog preseka PPU kod 33 kV kablovskog voda koji je izrađen od tri jednožilna kabla u trougaonoj formaciji. Razmatrani su slučajevi sa velikim poprečnim presecima provodnika – od 800 i 1000 mm^2, kod koji su metalni ekrani uzemljeni samo na jednom kraju i kod kog se primenjuje PPU.

The authors discussed the application of parallel grounding conductor (PGC) in medium-voltage cable lines as well as methods for determining its minimum cross-sectional area. Following the introduction, various methods for connecting the metallic screens of medium-voltage cables using PGC were described in the paper. Then, two methods for determining the minimum cross-sectional area of PGC in medium-voltage cables with metallic screens grounded only at one end were explained. The paper also provides an example calculation of the minimum cross-sectional area of PGC in a 33 kV cable line made of three single-core cables in a triangular formation. Cases with large conductor cross-sections - of 800 and 1000 mm2 - were considered, where the metallic screens are grounded only at one end and PGC is applied.

Pitanja za diskusiju / *Questions for discussion*

1. Zbog čega je neophodna primena paralelnog provodnika uzemljenja kod srednjenaponskih kablovskih vodova?
2. U radu je prikazano da se vrši transponovanje paralelnog provodnika uzemljenja. Zbog čega se to radi?
3. Od čega će dominantno zavisiti vrednost minimalnog poprečnog preseka provodnika koji povezuje dva uzemljivača? Kako usvojena vrednost poprečnog preseka utiče na struju zemljospoja?
4. Zbog čega je razmatran kablovski vod naponskog nivoa 33 kV?

1. *Why is the implementation of parallel grounding conductor necessary for medium-voltage cable lines?*
2. *The transposition of the parallel grounding conductor is demonstrated in the paper. Why is this done?*
3. *What will primarily affect the value of the minimum cross-sectional area of the conductor connecting two grounding points? How does the adopted value of the cross-sectional area affect the ground fault current?*
4. *Why was a cable line of the 33 kV voltage level considered?*

R-1.13.

SOFTVERSKA REALIZACIJA PRORAČUNSKE METODE ZA IZRAČUNAVANJE STRUJA KRATKOG SPOJA KROZ NAMOTAJE TRANSFORMATORA

SOFTWARE IMPLEMENTATION OF THE METHOD FOR SHORT CIRCUIT CALCULATION THROUGH TRANSFORMER WINDINGS

Anastasija Popović, Marko Novković, Tomislav Rajić, Zoran Radaković

Rad prikazuje softversku realizaciju proračunske metode za izračunavanje struja kratkog spoja kroz namotaje transformatora prikazane u radu prezentovanom na CIRED Srbija 2022. godine. Softver je realizovan u programskom jeziku C#.

The paper presents software implementation of the method for short circuit current calculation through transformer windings given in the paper presented at CIRED Serbia Conference in 2022. The software is developed in the C# programming language.

Pitanja za diskusiju / *Questions for discussion*

1. Kakve su mogućnosti povezivanja, odnosno zajedničkog korišćenja razvijenog programa sa programima navedenim u poglavlju 2 (na primer, razmena ulaznih i izlaznih podataka, i sl.)?
2. Pošto su autori razvili više programa polazeći od MS Excel-a, prelazeći na C#, da li se planira neki sledeći korak (objedinjavanje u paket programa, povezivanjem sa drugim progmamima preko RPA alata i sl.)?

1. *What are the possibilities of connecting, that is, joint use of the developed program with the programs listed in chapter 2 (for example, exchange of input and output data, etc.)?*
2. *Since the authors developed several programs starting from MS Excel, moving to C#, is a next step planned (combined into a package of programs, connecting with other programs via RPA tools, etc.)?*

R-1.14.
TERMIČKI MONTORING ENERGETSKIH ULJNIH TRANSFORMATORA BAZIRAN NA PRIMENI DETALJNOG DINAMIČKOG TERMO-HIDRAULIČKOG MODELA
THERMAL MONITORING OF LIQUID IMMERSED POWER TRANSFORMERS BASED ON DETAILED DYNAMIC THERMAL-HYDRAULIC MODEL
Marko Novković, Patrick Picher, Federico Torriano, Zoran Radaković

Kako bi se opterećivanje transformatora preko nominalne vrednosti sprovelo na bezbedan način, neophodna je upotreba dinamičkih termičkih modela za određivanje temperature kritičnih delova transformatora tokom termičkih prelaznih procesa. U radu su prikazane osnove detaljnog dinamičkog termo-hidrauličkog mrežnog modela (THMM), kao i njegova primena na trofaznom transformatoru snage 66 MVA i monofaznom transformatoru snage 370 MVA.

In order to load the transformer beyond the rated value in a safe way, it is necessary to use dynamic thermal models to determine the temperature of the critical parts of the transformer during thermal transient processes. The paper presents the basics of a detailed dynamic thermo-hydraulic network model (THNM), as well as its application on a 66 MVA three-phase transformer and a 370 MVA single-phase transformer.

Pitanja za diskusiju / *Questions for discussion*

1. Koje su prednosti primene dinamičkog termo-hidrauličkog mrežnog modela (THMM)?

1. *What are the advantages of the application of dynamic thermal hydraulic network model (THNM)?*

R-1.15.
OBJEDINJAVANJE TEHNIČKE DOKUMENTACIJE ZA IZGRADNJU OBJEKATA
CONSOLIDATION OF TECHNICAL DOCUMENTATION FOR THE CONSTRUCTION OF FACILITIES
Dragoslav Perić

U radu je dat predlog izrade i kompletiranja tehničke projektne dokumentacije korišćenjem programa za tabelarne proračune. Cilj ovakvog načina rada je jednostavniji unos i ažuriranje podataka koji se pojavljuju na više mesta u različitim dokumentima i ušteda vremena pri izradi tehničke dokumentacije.

The paper presents a proposal for creating and completing project technical documentation using spreadsheet programmes. The goal of this way of working is simpler data entry and updating that appear in several places in different documents and saving time when creating technical documentation.

Pitanja za diskusiju / *Questions for discussion*

1. U radu su date sve prednosti ako se opšta, tekstualna i numerička dokumentacija rade u programima za tabelarne proračune. Da li postoje i nedostaci u odnosu na izradu dokumentacije u programima za obradu teksta, s obzirom da projektna dokumentacija uglavnom sadrži veliku količinu teksta a programi za tabelarne proračune i nisu baš pogodni za rad sa tekstom (npr. vizuelni izgled teksta, prelom teksta, itd.)

1. *In the paper, all advantages are given if general, textual and numerical documentation is done in spreadsheet programmes. Are there any disadvantages in relation to the creation of documentation in word processing programmes, given that project documentation generally contains a large amount of text and spreadsheet programmes are not very suitable for working with text (e.g. visual appearance of text, text break, etc.)?*

2. Ima li autor informaciju da li postoje i specijalizovani programi za objedinjavanje izrade tehničke dokumentacije

2. *Does the author have information on whether there are specialized programmes for unifying the production of technical documentation?*

STK 1 / *EC 1*: Preferencijalna tema 4 / *Preferential Subject 4*:
Uticaj komponenti elektrodistributivnih mreža
The impact of network components

R-1.16.
ANALIZA BEZBEDNOSTI RADNIKA PRILIKOM OBAVLJANJA RADOVA NA DVOSISTEMSKOM NADZEMNOM VODU NAPONSKOG NIVOA 35 KV
ANALYSIS OF THE SAFETY OF WORKERS DURING WORKS ON 35 KV DOUBLE-CIRCUIT OVERHEAD POWER LINE
Maja Grbić, Aleksandar Pavlović, Ranko Jasika, Stefan Obradović, Katarina Maksić, Časlav Petrović, Nenad Ristović

U analizi bezbednosnih rizika radova na distributivnom vodu naponskog nivoa 35 kV na zajedničkim stubovima s drugim vodom istog naponskog nivoa, razmatrana su četiri načina uzemljenja. Najveći rizik je bio kada pasivni vod nije bio uzemljen u krajnjim tačkama i uzemljen je samo na stubu na kome se obavljaju radovi. Napon dodira u svim slučajevima je bio ispod bezbednih vrednosti. Analizirani su i rizici od napona dodira i koraka u okolini stuba, pokazujući da je najveći rizik na prvom stubu nakon razdvajanja dvosistemskog voda, ali vrednosti napona koraka nisu prekoračile granicu. Kao što je i očekivano, uzemljenje pasivnog voda na oba kraja povećava bezbednost radnika.

In the analysis of the safety risks of works on the distribution line with a voltage level of 35 kV on common poles with another line of the same voltage level, four methods of grounding were considered. The greatest risk was when the passive line was not grounded at the end points and was grounded only on the pole where the work was being done. The touch voltage in all cases was below safe values. The risks of touch and step voltages in the vicinity of the pole were also analyzed, showing that the greatest risk is on the first pole after the separation of the two-system line, but the step voltage values did not exceed the limit. As expected, grounding the passive line at both ends increases worker safety.

Pitanja za diskusiju / *Questions for discussion*

1. Da li bi drugačiji izgled glave stuba i oblik uzemljivača promenio rezultate i koliko?
2. Da li dužina kablovske deonice utiče na rezultate?

1. *Would a different look of the pole head and the shape of the grounder change the results and by how much?*
2. *Does the length of the cable section affect the results?*

R-1.17.
ANALIZA NIVOA MAGNETSKE INDUKCIJE U ZONI POVEĆANE OSETLJIVOSTI IZNAD TRANSFORMATORSKE STANICE NAPONSKOG NIVOA 10/0,4 KV
ANALYSIS OF MAGNETIC FLUX DENSITY LEVELS IN THE INCREASED SENSITIVITY AREA LOCATED ABOVE THE 10/0.4 KV SUBSTATION
Maja Grbić, Aleksandar Pavlović

U radu su prikazana merenja magnetske indukcije u zonama povećane osetljivosti koje se nalaze iznad transformatorskih stanica naponskog nivoa 10/0,4 kV kod kojih se šinske veze koje povezuju transformator i razvod niskog napona nalaze u neposrednoj blizini plafona i predstavljaju izvor magnetskog polja u zoni povećane osetljivosti. Prikazani su i sprovedeni proračuni magnetske indukcije za slučajeve transformatora koji su najčešće primenjeni u stambenim zgradama, za različita rastojanja od šina. Izvršenim merenjima i proračunima je ustanovljeno da je, za slučajeve gde se utvrdi mogućnost prekoračenja referentne vrednosti, potrebno sprovesti mere za smanjenje nivoa magnetskog polja.

The paper presents measurements of magnetic induction in zones of increased sensitivity located above substations 10/0.4 kV where the rail connections connecting the transformer and the low voltage distribution are located in the immediate vicinity of the ceiling and represent the source of the magnetic field in the zone of increased sensitivity. Calculations of magnetic induction are presented and carried out for the cases of transformers that are most often used in residential buildings, for different distances from the rails. Based on the measurements and calculations, it was established that, in cases where the possibility of exceeding the reference value is determined, it is necessary to implement measures to reduce the level of the magnetic field.

Pitanja za diskusiju / *Questions for discussion*

1. Na koliko transformatorskih stanica 10/0,4 kV su do sada izvršena navedena merenja? Da li je moguće proceniti na koliko transformatorskih stanica 10/0,4 kV u jednom disitributivnom području ili jednom ogranku, postoji mogućnost prekoračenja referentne vrednosti nivoa magnetske indukcije?
2. Da li su u nekim transformatorskim stanicama izvršena merenja vrednosti magnetske indukcije nakon sprovođenja mera za smanjenje i da li su se postigli zadovoljavajući rezultati?

1. *At how many 10/0.4 kV substations have the above measurements been performed so far? Is it possible to estimate how many 10/0.4 kV substations in one distributive area or one branch, there is a possibility of exceeding the reference value of the level of magnetic induction?*
2. *Were measurements of magnetic induction values performed in some substations after the implementation of reduction measures and were satisfactory results achieved?*

I-1.18.
UTICAJ SOLARNIH FOTONAPONSKIH ELEKTRANA NA ŽIVOTNU SREDINU
IMPACT OF SOLAR PHOTOVOLTAIC POWER PLANTS ON THE ENVIRONMENT
Bogdan Petrović, Siniša Spremić

Rad daje pregled uticaja solarnih fotonaponskih elektrana na životnu sredinu na osnovu javno raspoloživih podataka. Ukazuje se na potrebu praćenja ovih uticaja pre i nakon izgradnje.

The paper provides an overview of the environmental impact of solar photovoltaic power plants based on publicly available data. The need to monitor these impacts before and after construction is indicated.

Pitanja za diskusiju / *Questions for discussion*

1. Kakve su prognoze porasta solarnih fotonaponskih elektrana u Srbiji?
2. Da li za Srbiju postoje planovi za umanjivanje loših efekata izgradnjei eksploatacije solarnih fotonaponskih elektrana?

1. *What are the forecasts for the growth of solar photovoltaic power plants in Serbia?*
2. *Are there plans for Serbia to reduce the bad effects of the construction and operation of the solar photovoltaic power plants?*

Stručni izvestioci – recenzenti radova:

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